

Advanced Gamma Tracking Array

AGATA

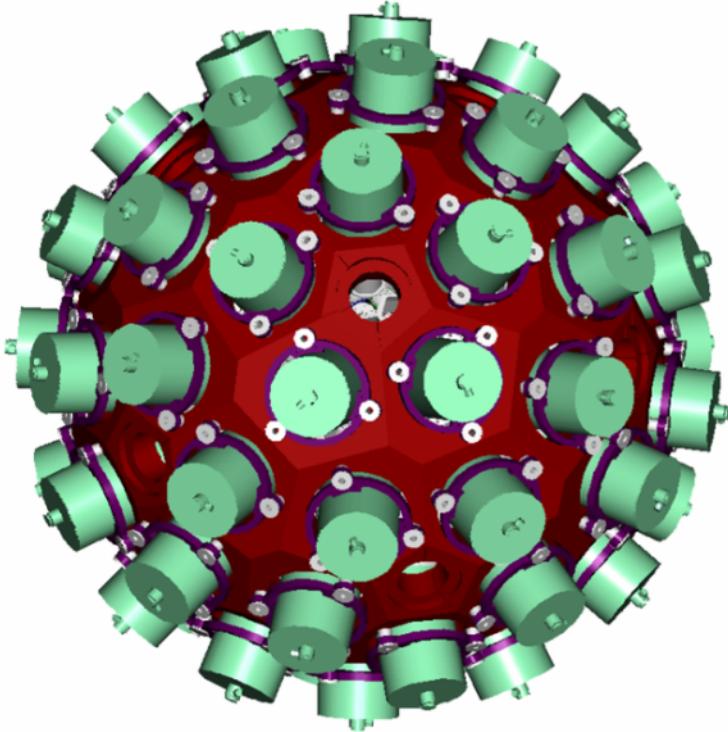
Andrea Gottardo, Dino Bazzacco
INFN LNL

On behalf of the AGATA Collaboration

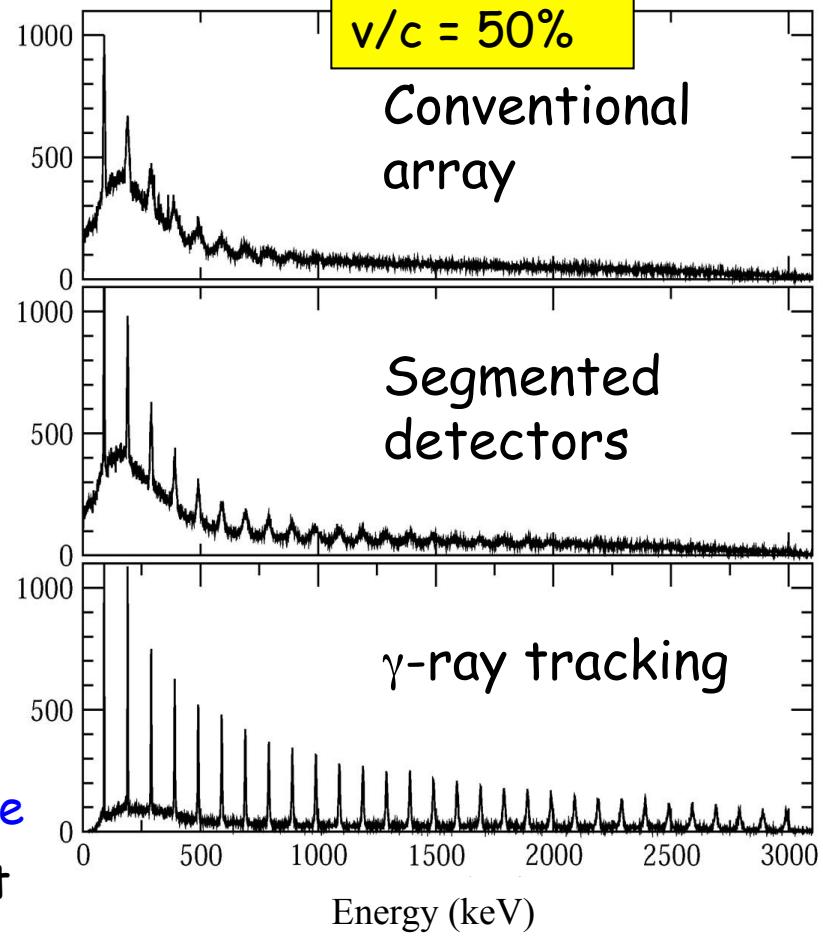
NS12, ANL, August 13-17, 2012



AGATA

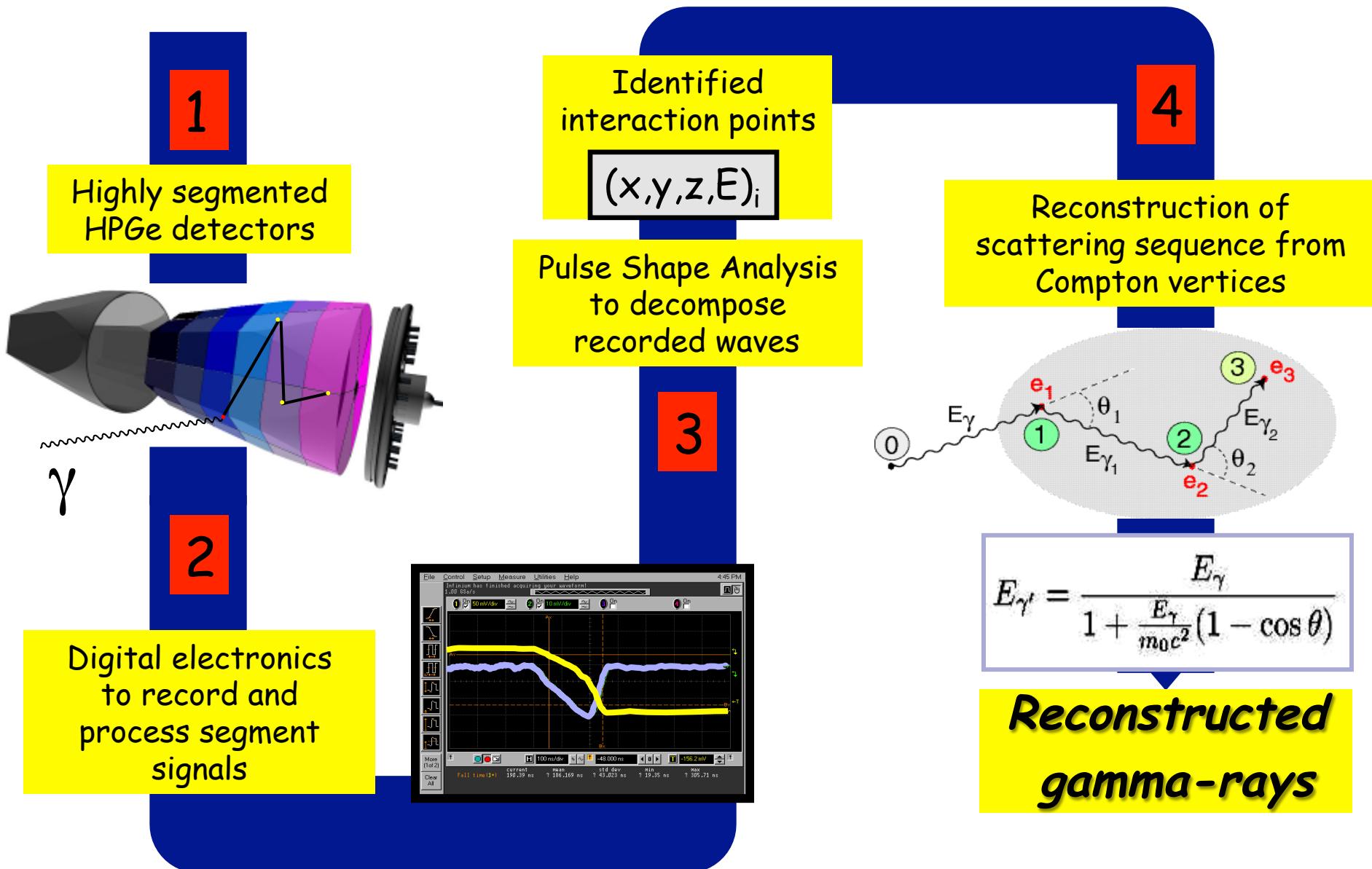
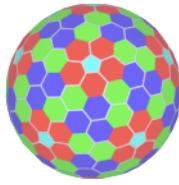


Using the detectors in **position-sensitive mode** will provide very high efficiency and excellent energy resolution, making AGATA ideal for spectroscopic studies of weak channels

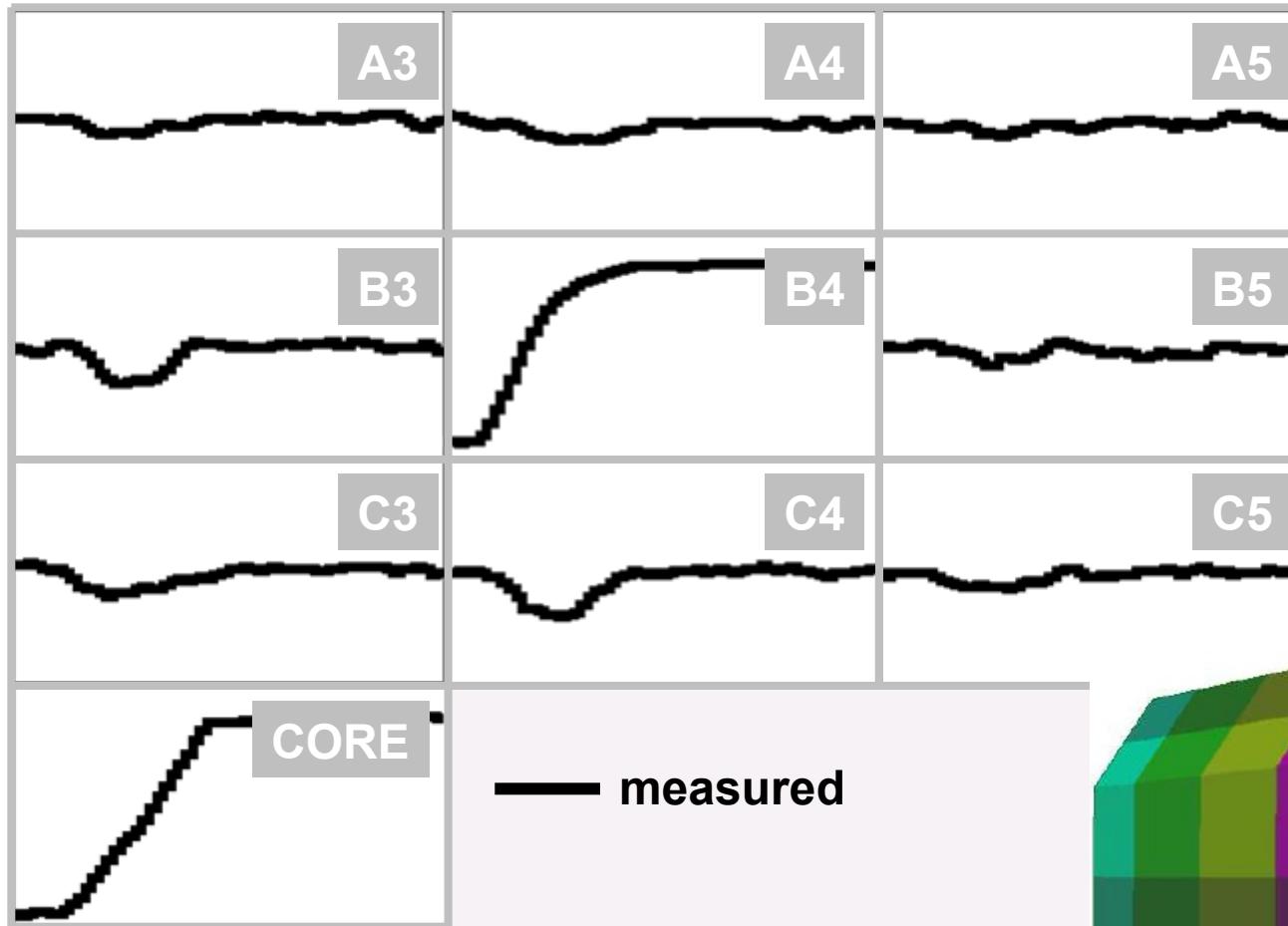


Effective energy resolution maintained at "extreme" v/c

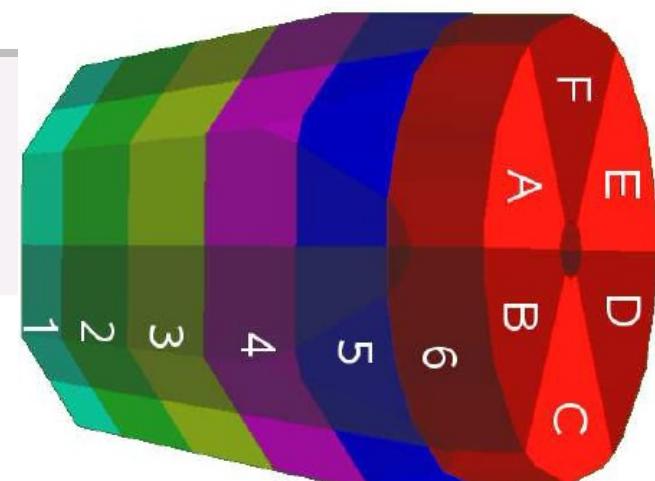
Gamma-ray tracking principle



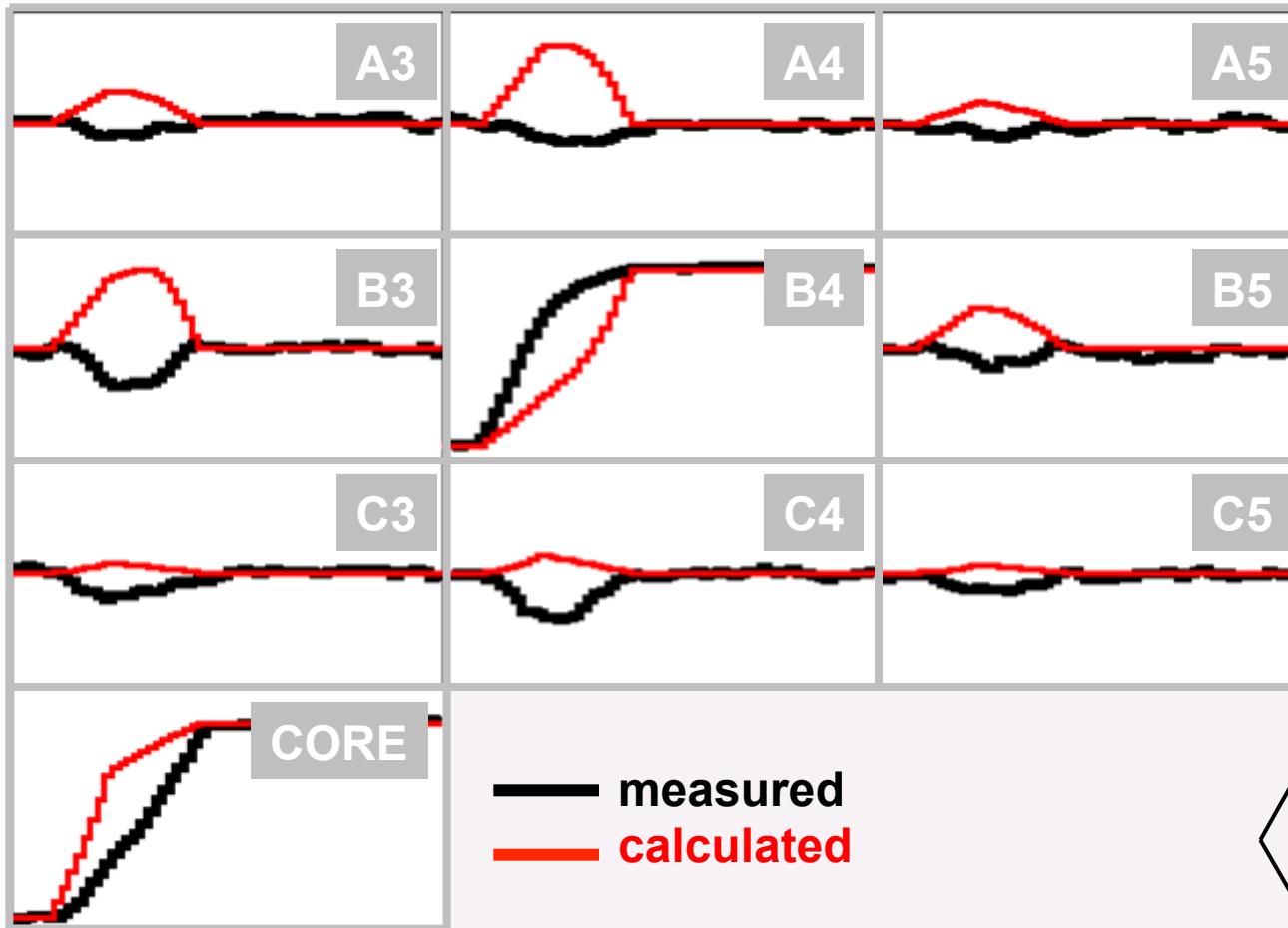
Pulse Shape Analysis concept



791 keV deposited in segment B4

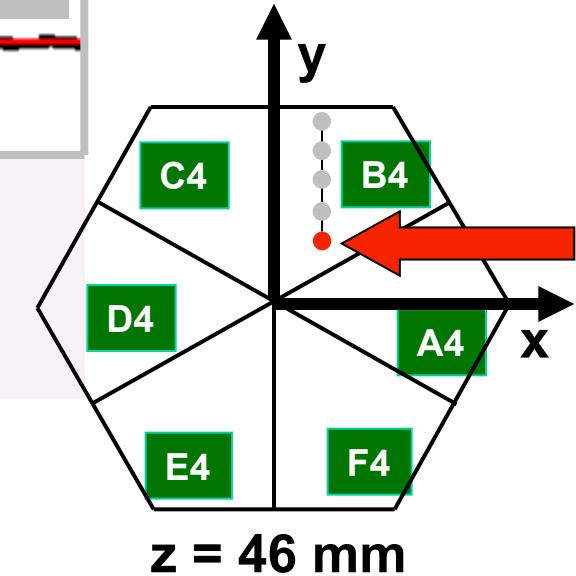


Pulse Shape Analysis concept

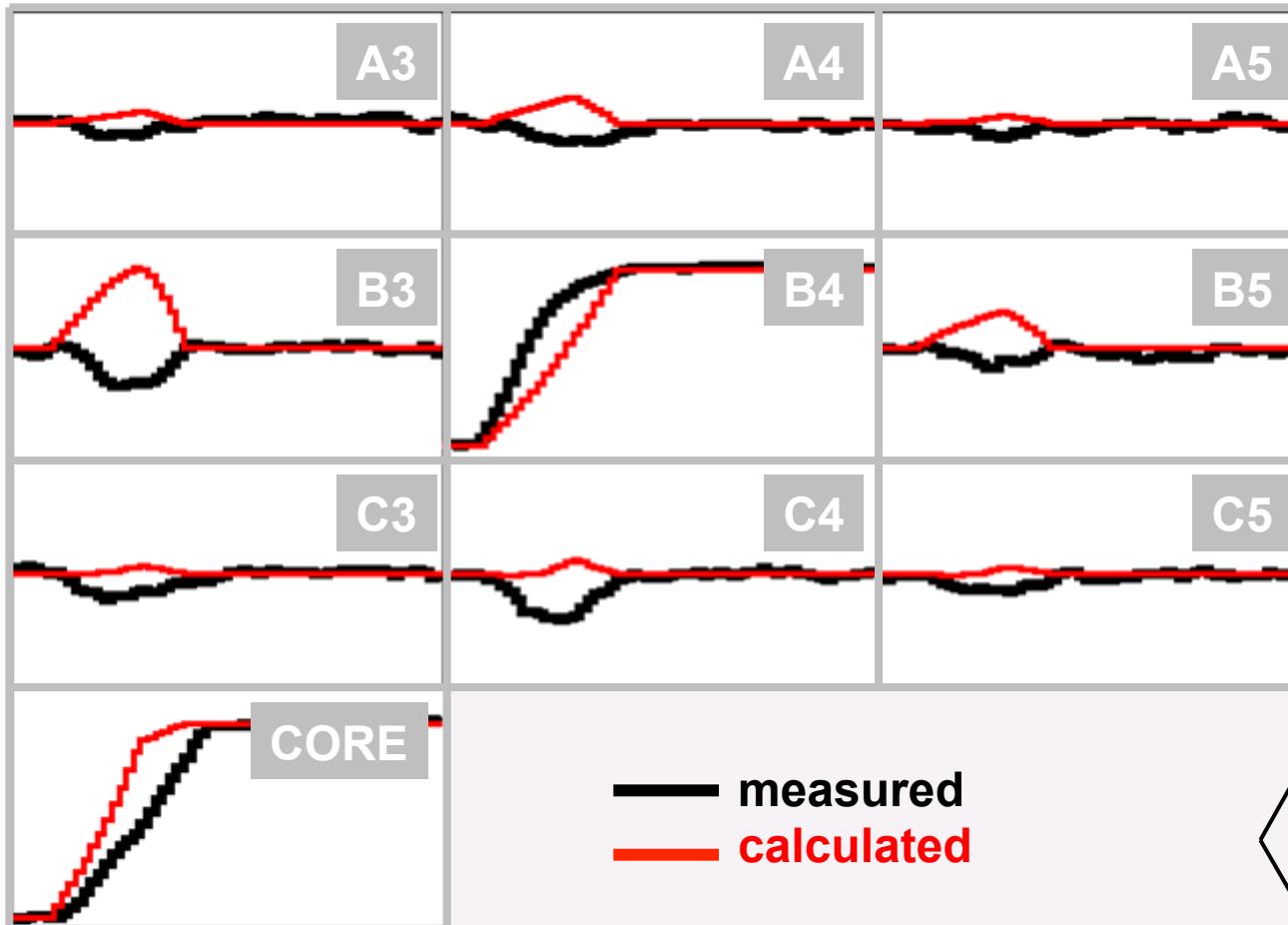


791 keV deposited in segment B4

(10, 10, 46)

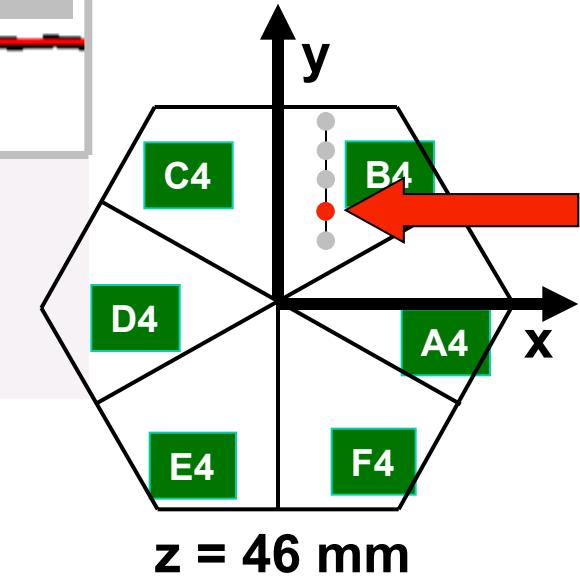


Pulse Shape Analysis concept

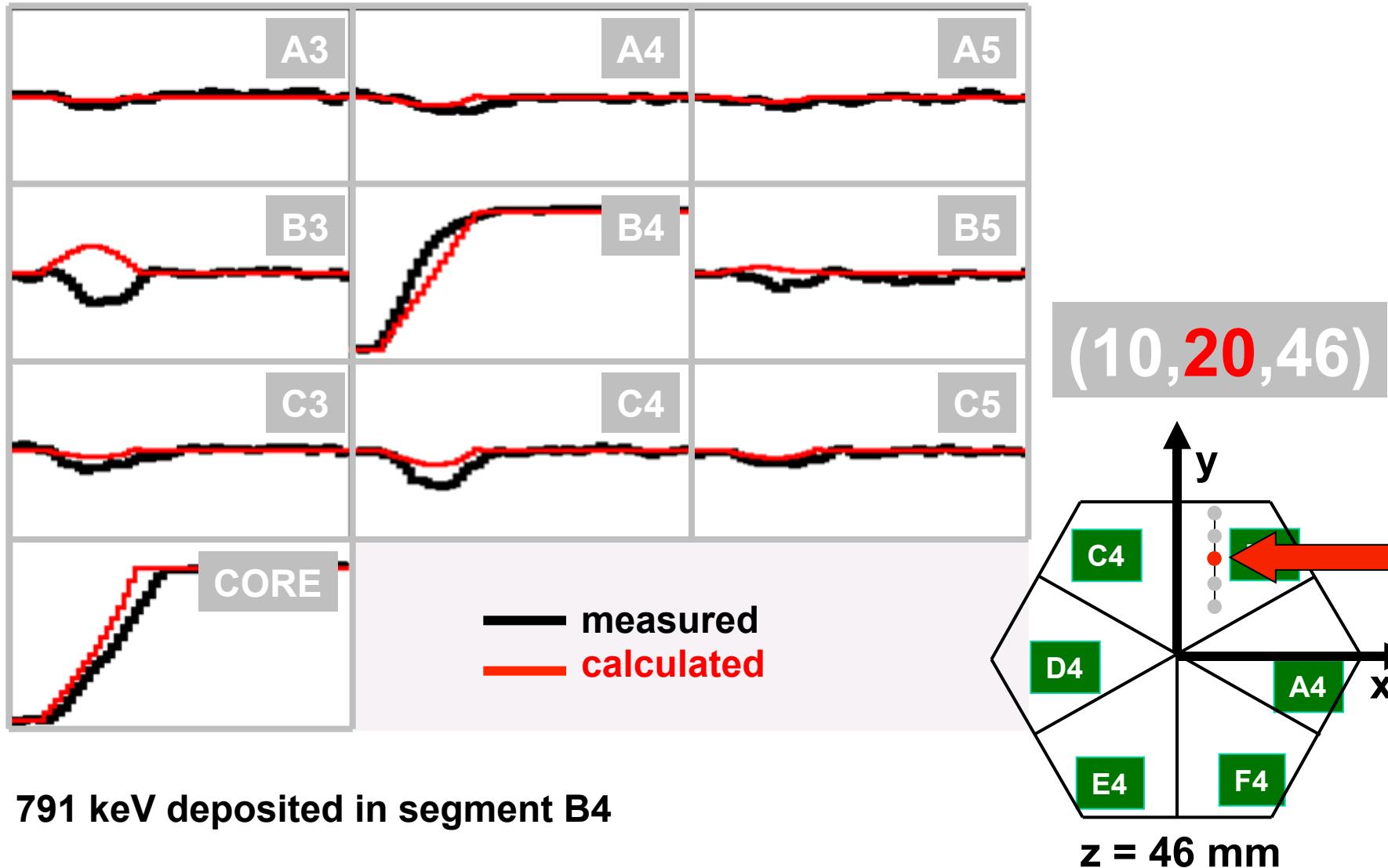


791 keV deposited in segment B4

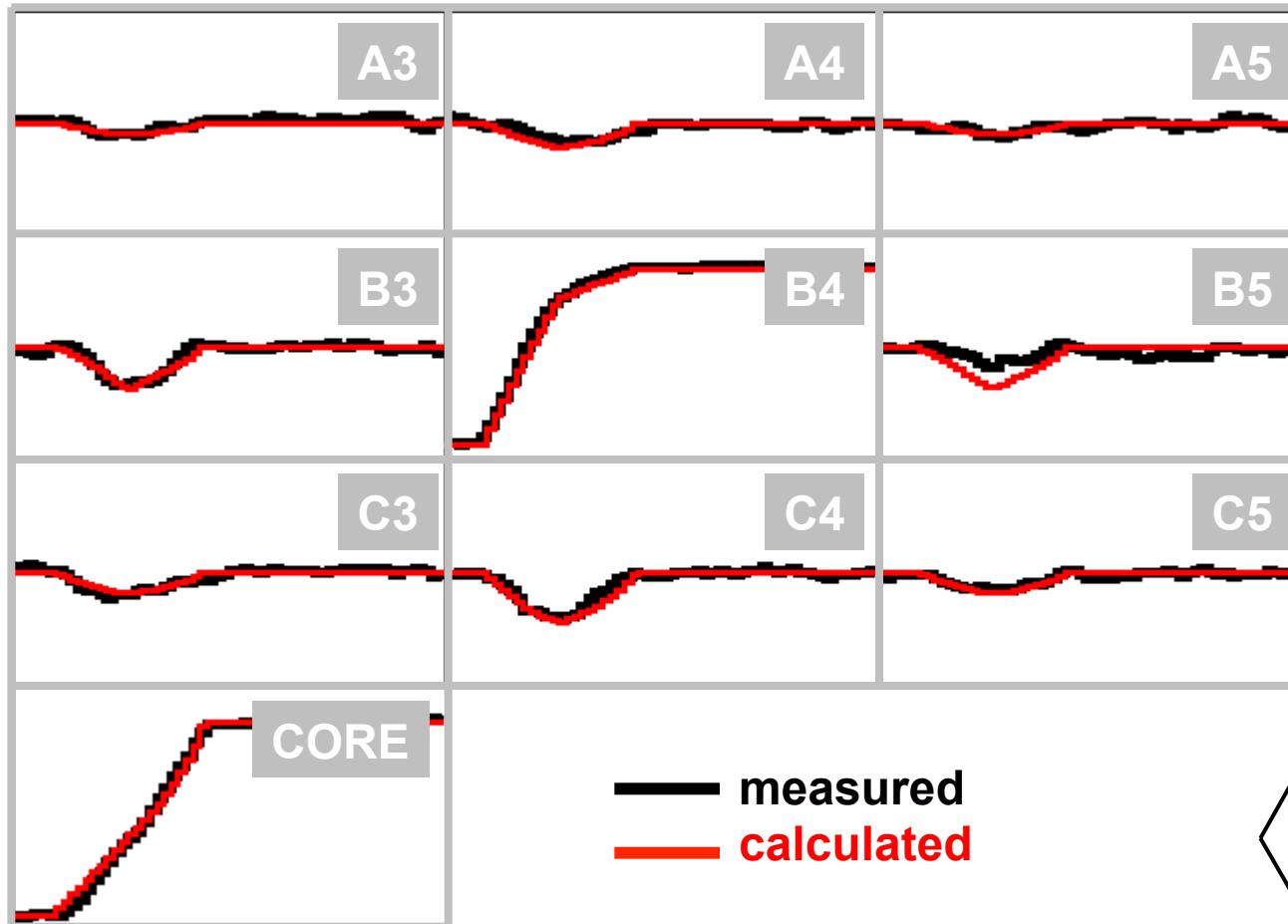
(10, 15, 46)



Pulse Shape Analysis concept

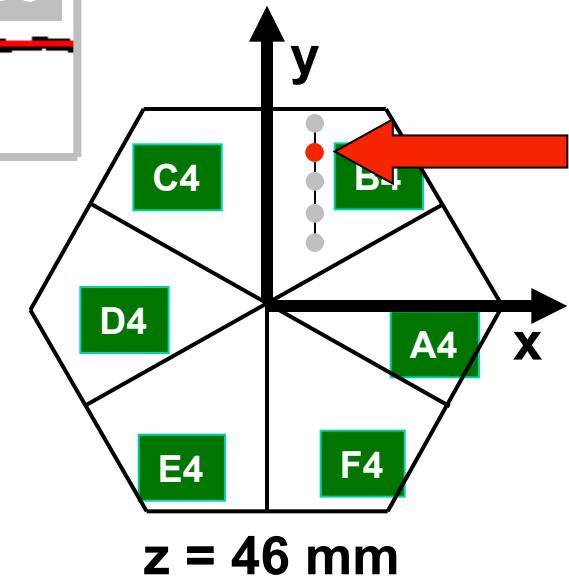


Pulse Shape Analysis concept

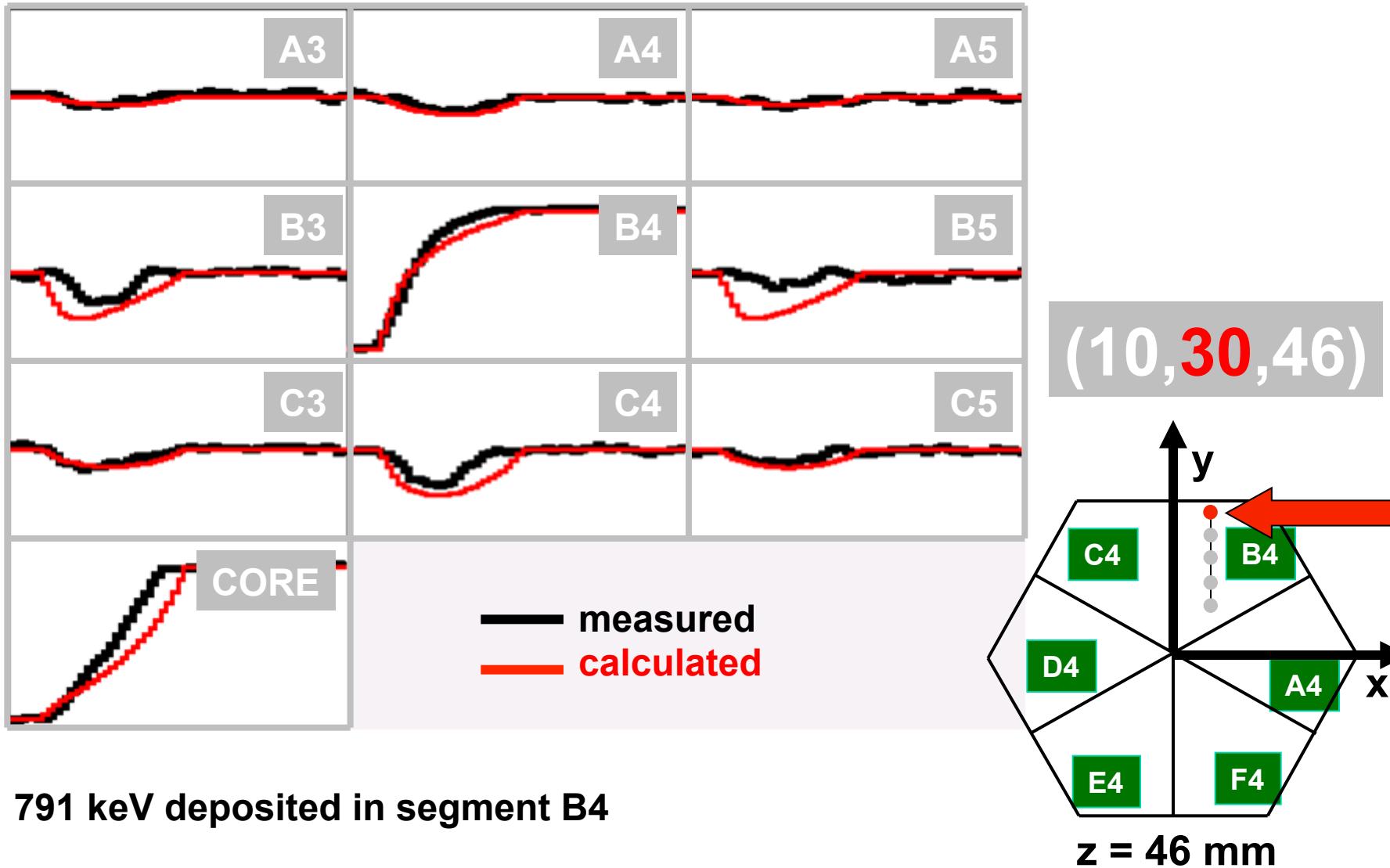


791 keV deposited in segment B4

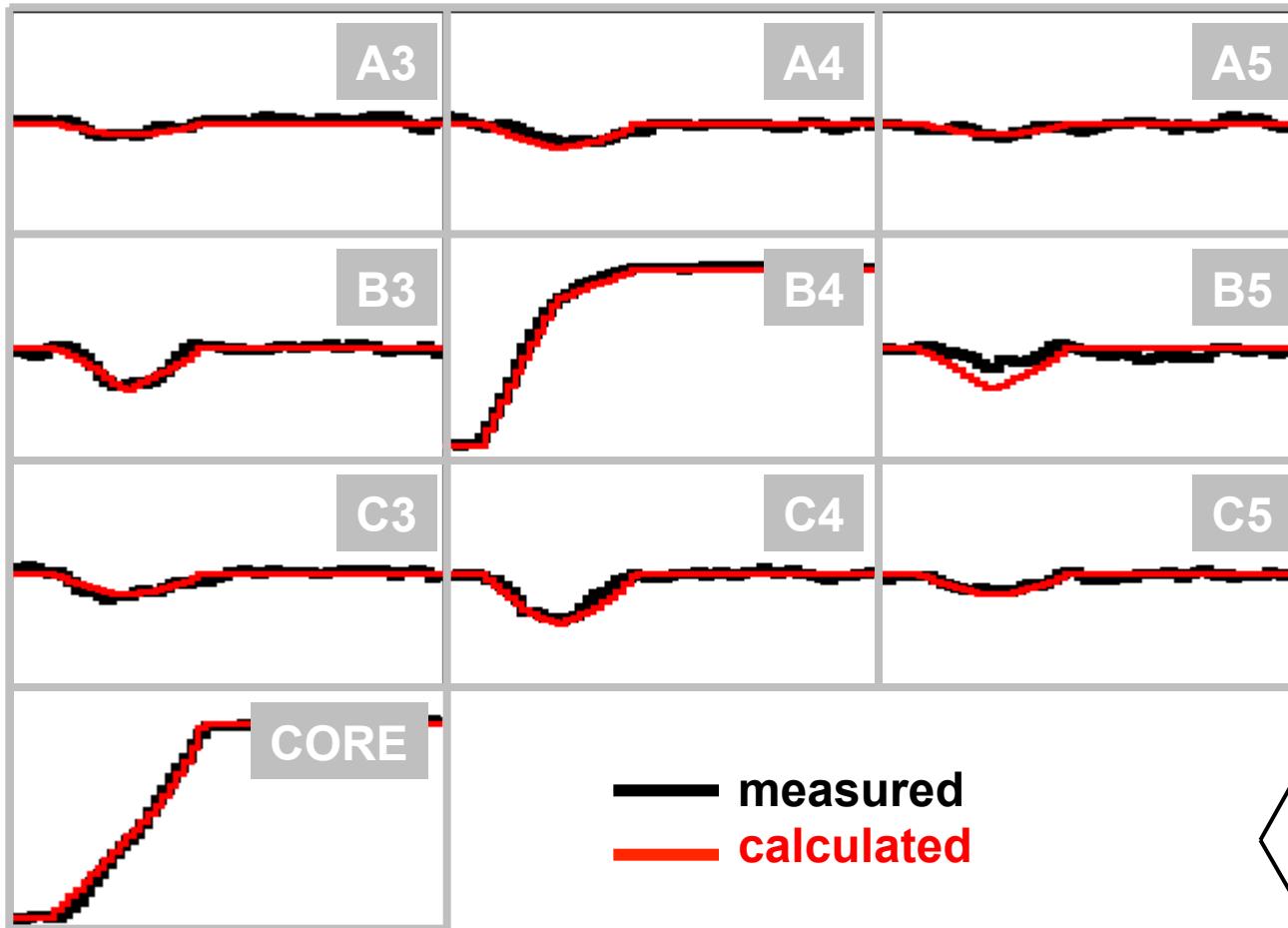
(10,25,46)



Pulse Shape Analysis concept

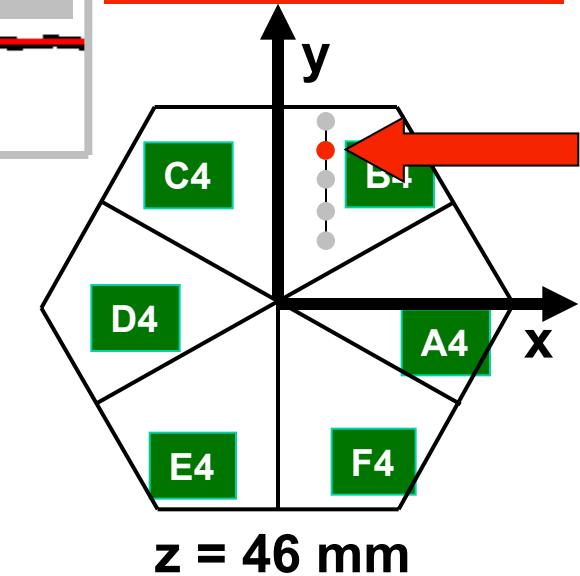


Pulse Shape Analysis concept



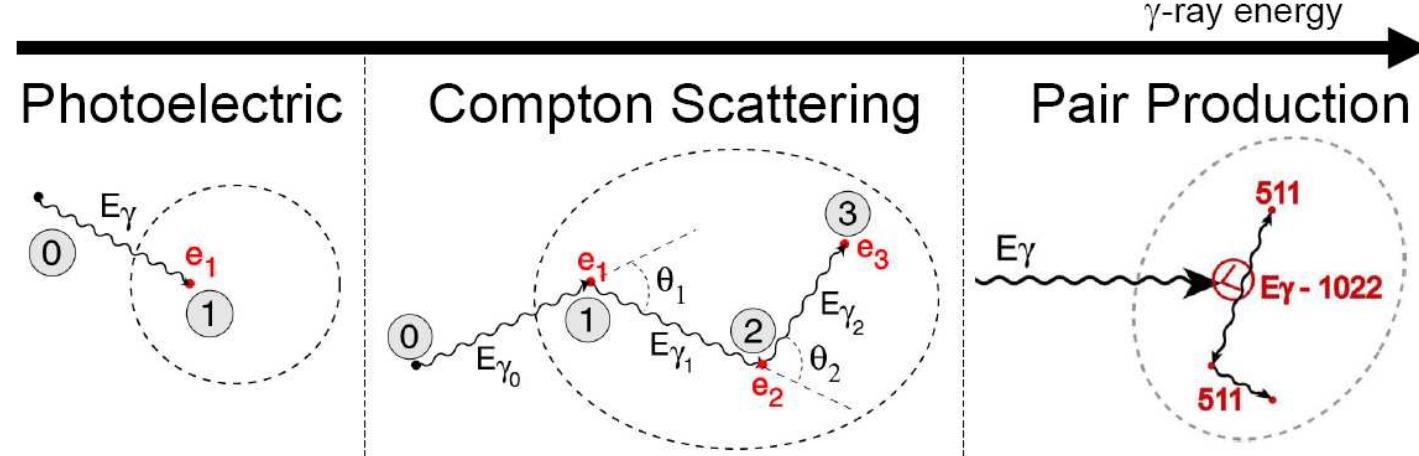
Result of
Grid Search
Algorithm

(10, 25, 46)

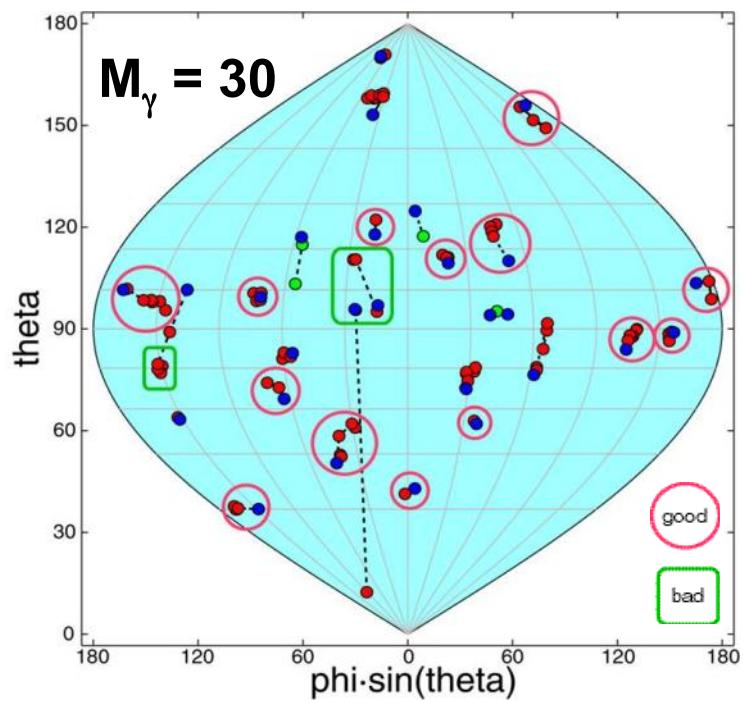


791 keV deposited in segment B4

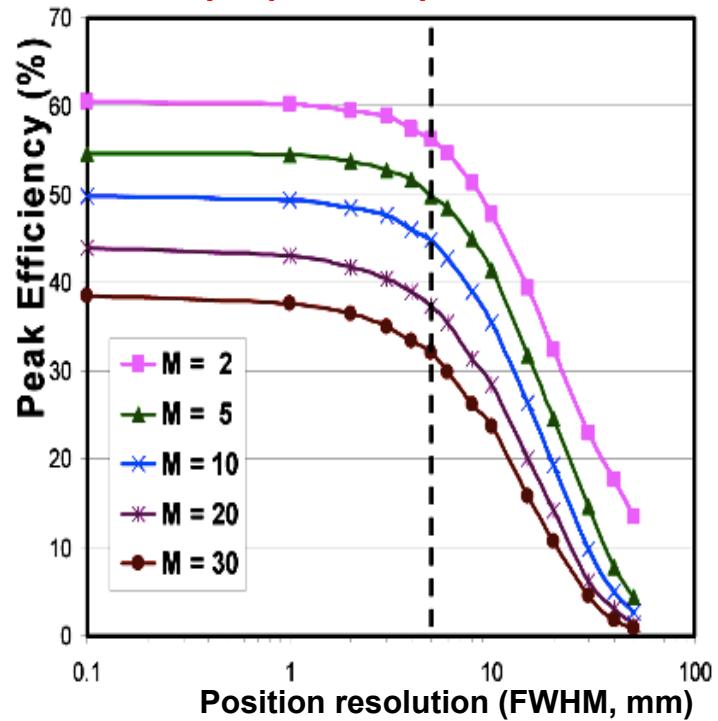
Reconstruction of 0.1÷10 MeV gammas



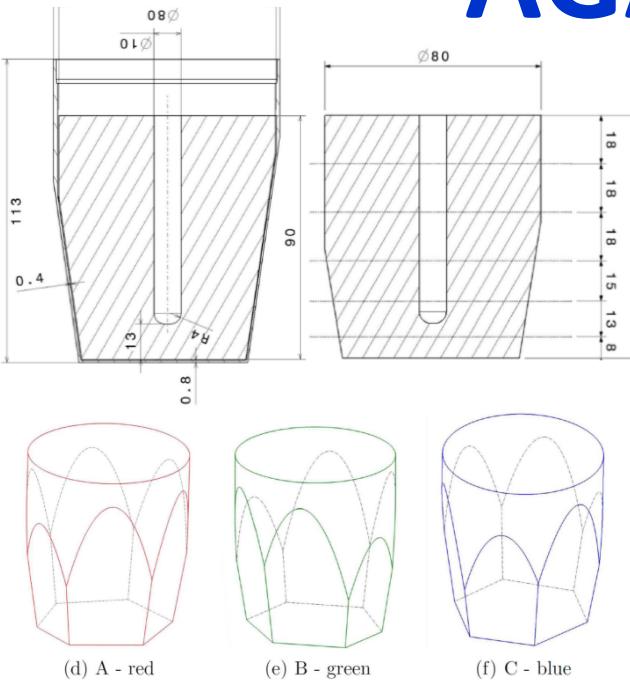
MC simulation of a high-multiplicity event



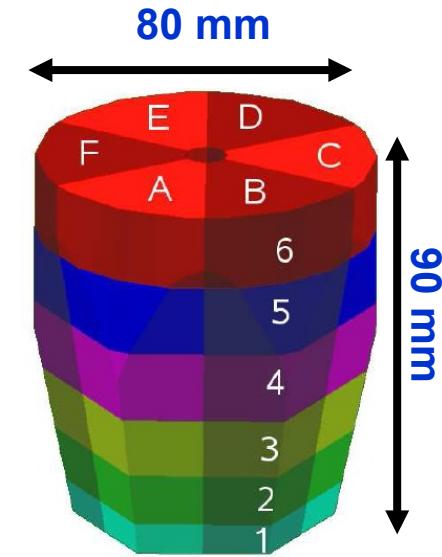
Efficiency depends on position resolution



AGATA Detectors



Volume ~370 cc Weight ~2 kg
(shapes are volume-equalized to 1%)

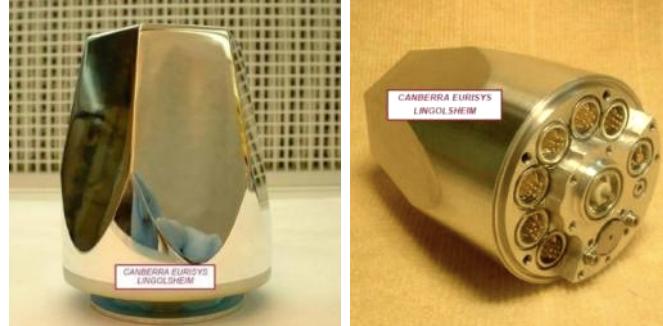


6x6 segmented cathode

Cold FET for all signals

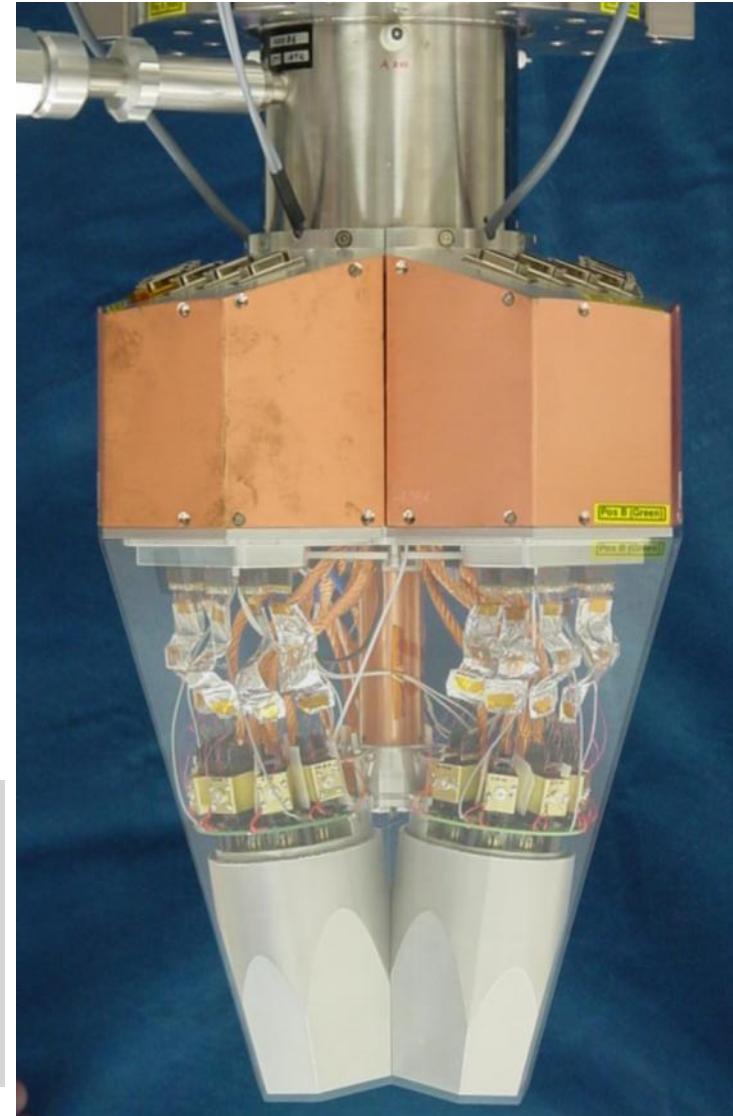
Energy resolution
Core: 2.35 keV
Segments: 2.10 keV
(FWHM @ 1332 keV)

A. Wiens et al. NIM A 618 (2010) 223
D. Lersch et al. NIM A 640(2011) 133



AGATA Asymmetric Crystals

Manufactured by Canberra France



AGATA Asymmetric Triple Cryostat

Manufactured by CTT

The AGATA Demonstrator

Objective of the R&D phase 2003-2009

Used for Physics at LNL in 2010-2011

5 asymmetric triple-clusters

15 36-fold segmented crystals

540 segments

555 high-resolution digital-channels

Eff. 3 – 8 % @ $M_{\gamma} = 1$

Eff. 2 – 4 % @ $M_{\gamma} = 30$

Real time operation

Pulse Shape Analysis

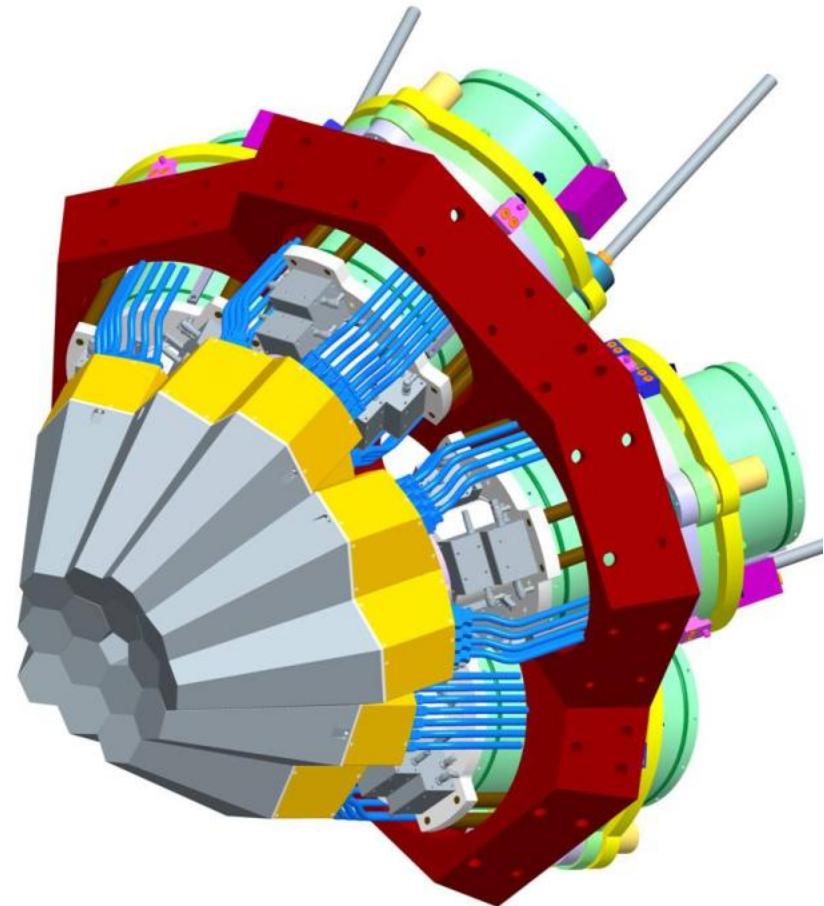
γ -ray Tracking

Hosting sites

LNL → 2009-2011

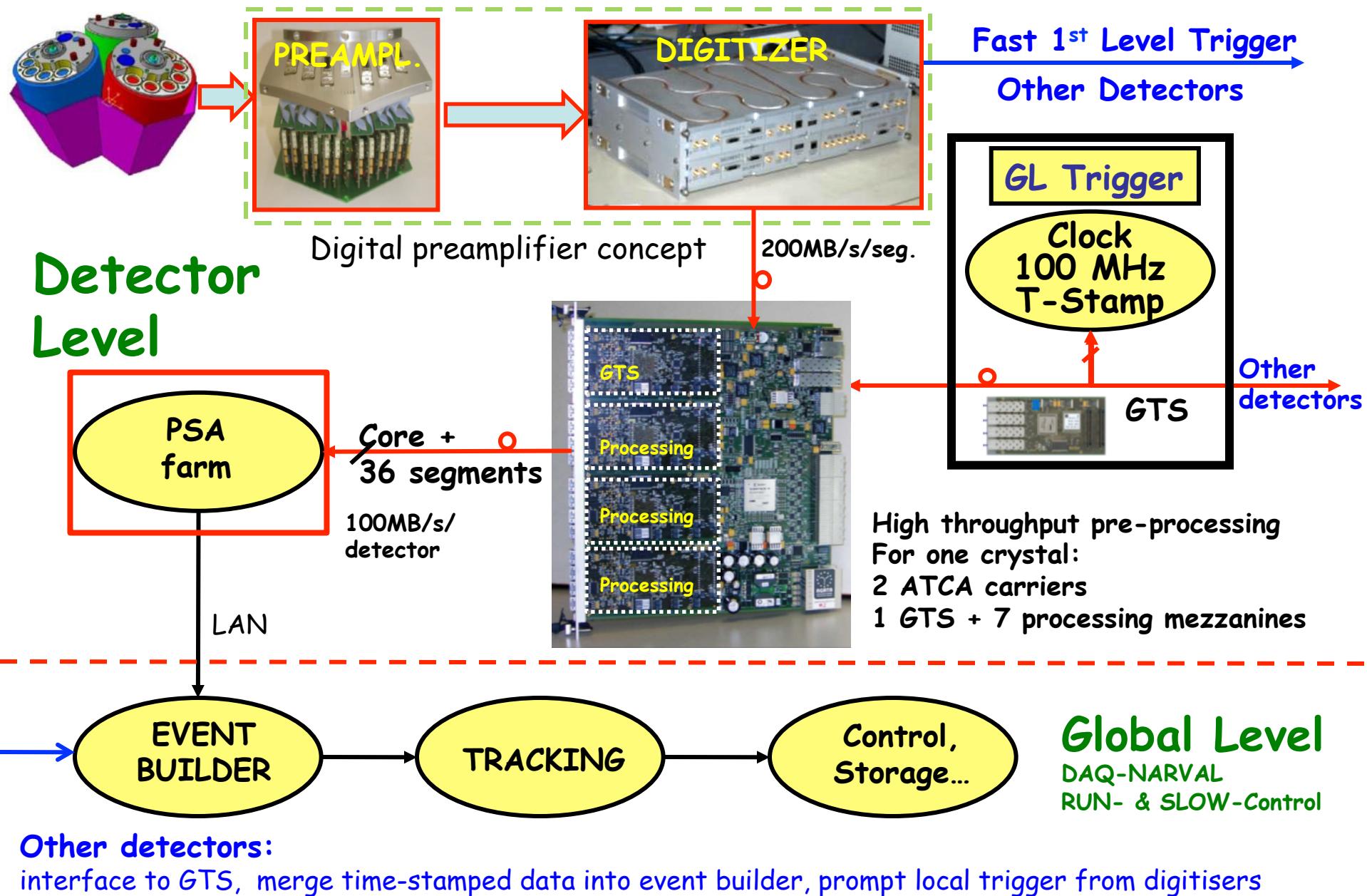
GSI → 2012-2013

GANIL → 2014-2015



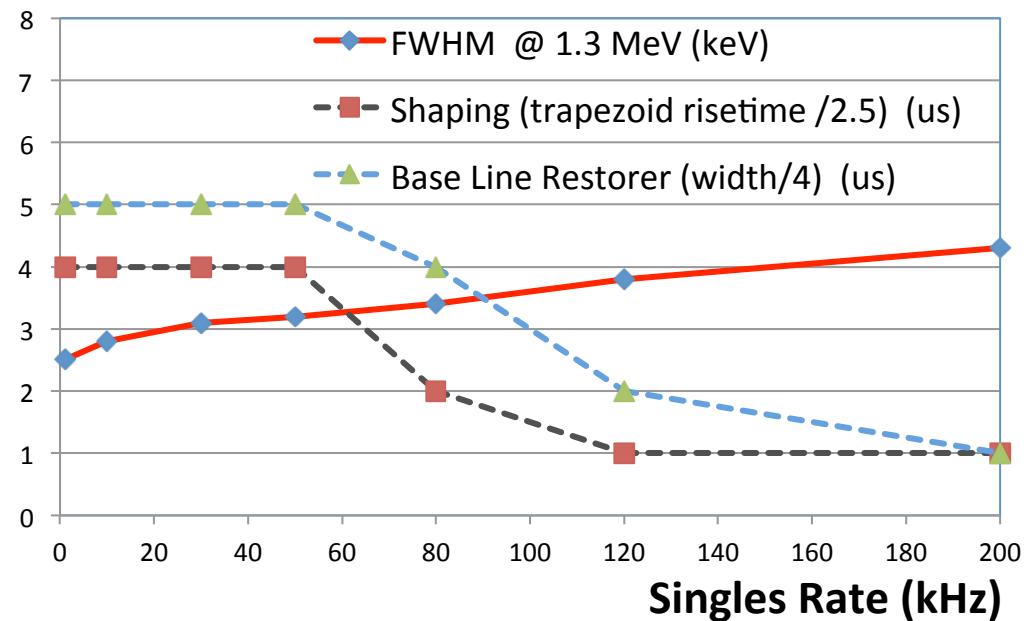
S. Akkoyun et al. NIM A 668 (2012) 26–58
A. Gadea et al. NIM A 654 (2011) 88-96

AGATA: Structure of Electronics and DAQ



High Count Rate Performance

- The detection efficiency of AGATA is, so far, provided by a small number of crystals.
- Experiments want to collect big statistics → need to run at high singles rates (> 50 kHz).
- Digital Signal Processing allows to work at rates “impossible” with analogue electronics.
- Under these «extreme» conditions, the performance of the detectors is still acceptable.

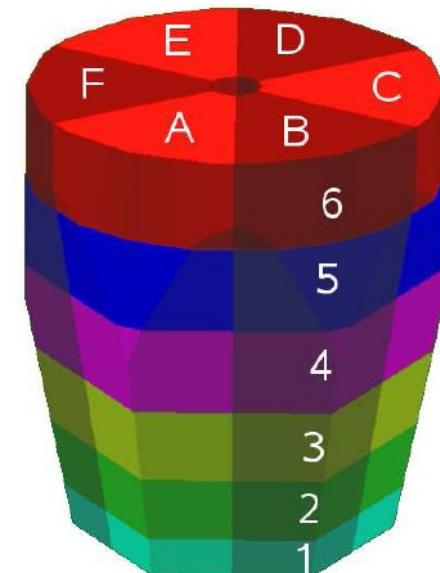
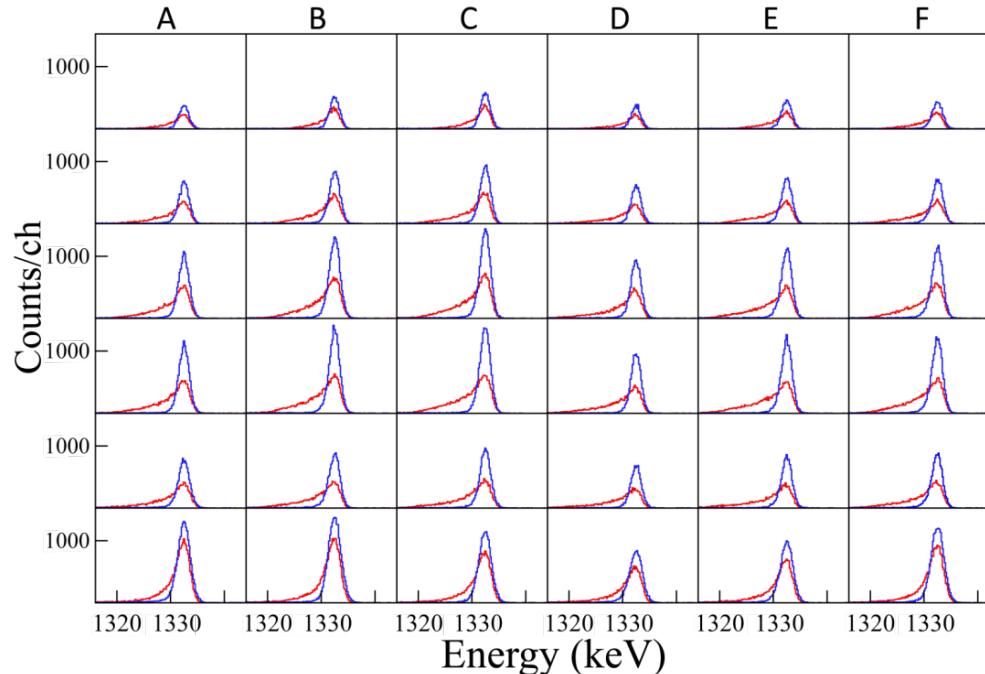


- A limit exists, due to pileup of the signals which exhausts the dynamical range of the FADC. Can counteract this by reducing the gain of the preamplifiers, but then energy resolution worsens also at low counting rate.
- However, running at high singles rates has consequences ...

Neutron Damage Problem

High reaction rates imply neutron damage and significant degradation of energy resolution for the segments

Damage after 3 high counting-rate experiments (3 weeks at 30-80 kHz singles)



Blue: April 2010 → FWHM(segments) ~2.0 keV

FWHM(core) ~2.3 keV

Red: July 2010 → FWHM(segments) ~3.5 keV

FWHM(core) ~2.4 keV

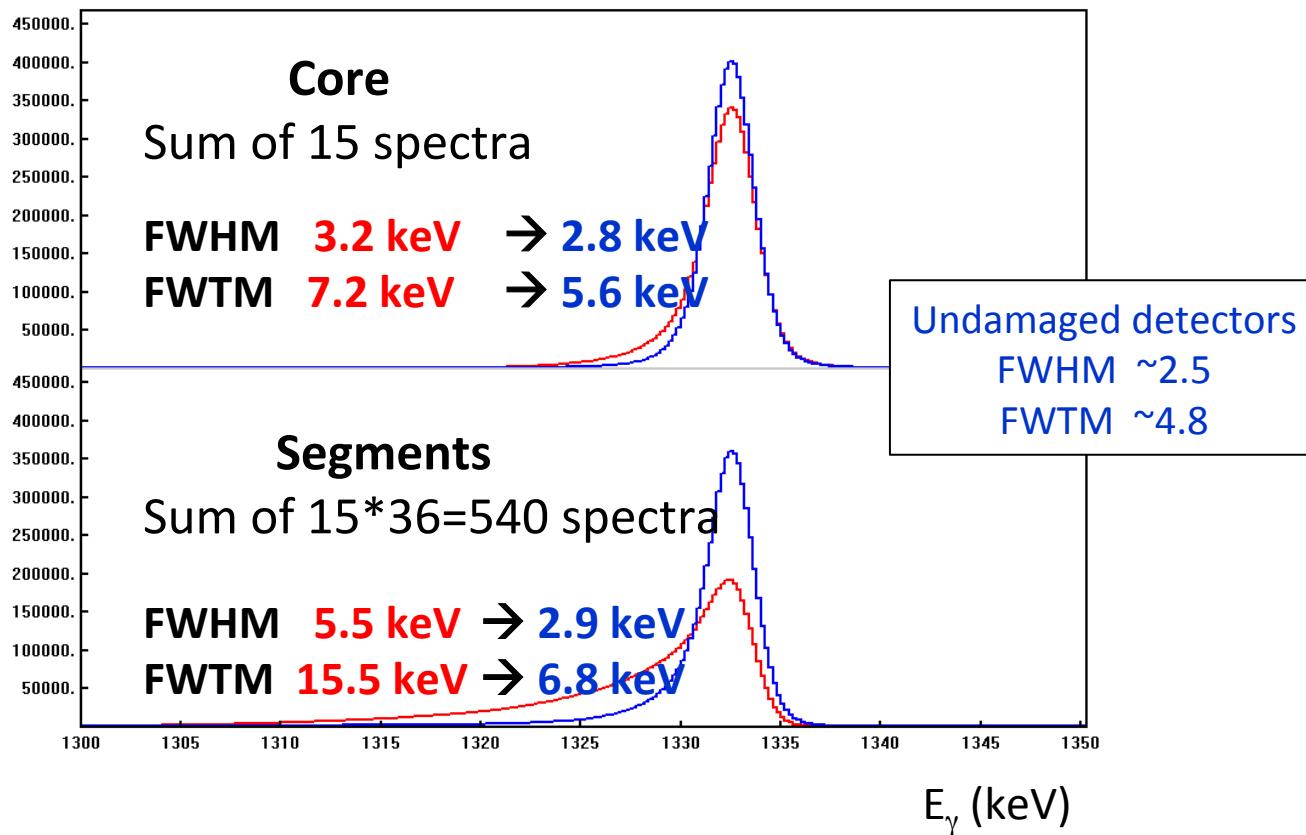
Worsening seen in all detectors (more in the forward ones)

Segments are the most affected

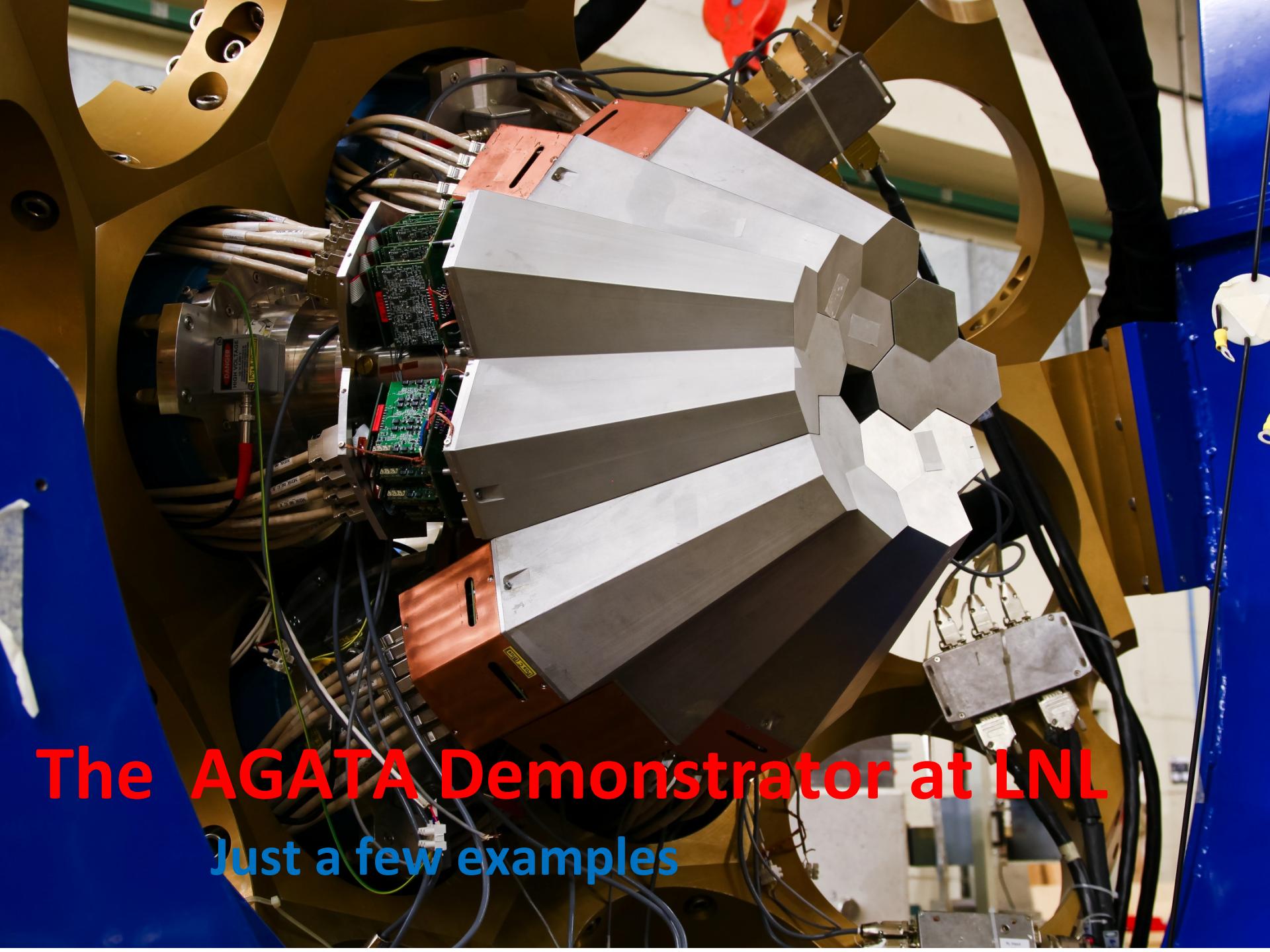
Cores almost unchanged (as expected for n-type HPGe)

Energy Resolution at the End of the LNL Campaign

Before and After charge-trapping correction



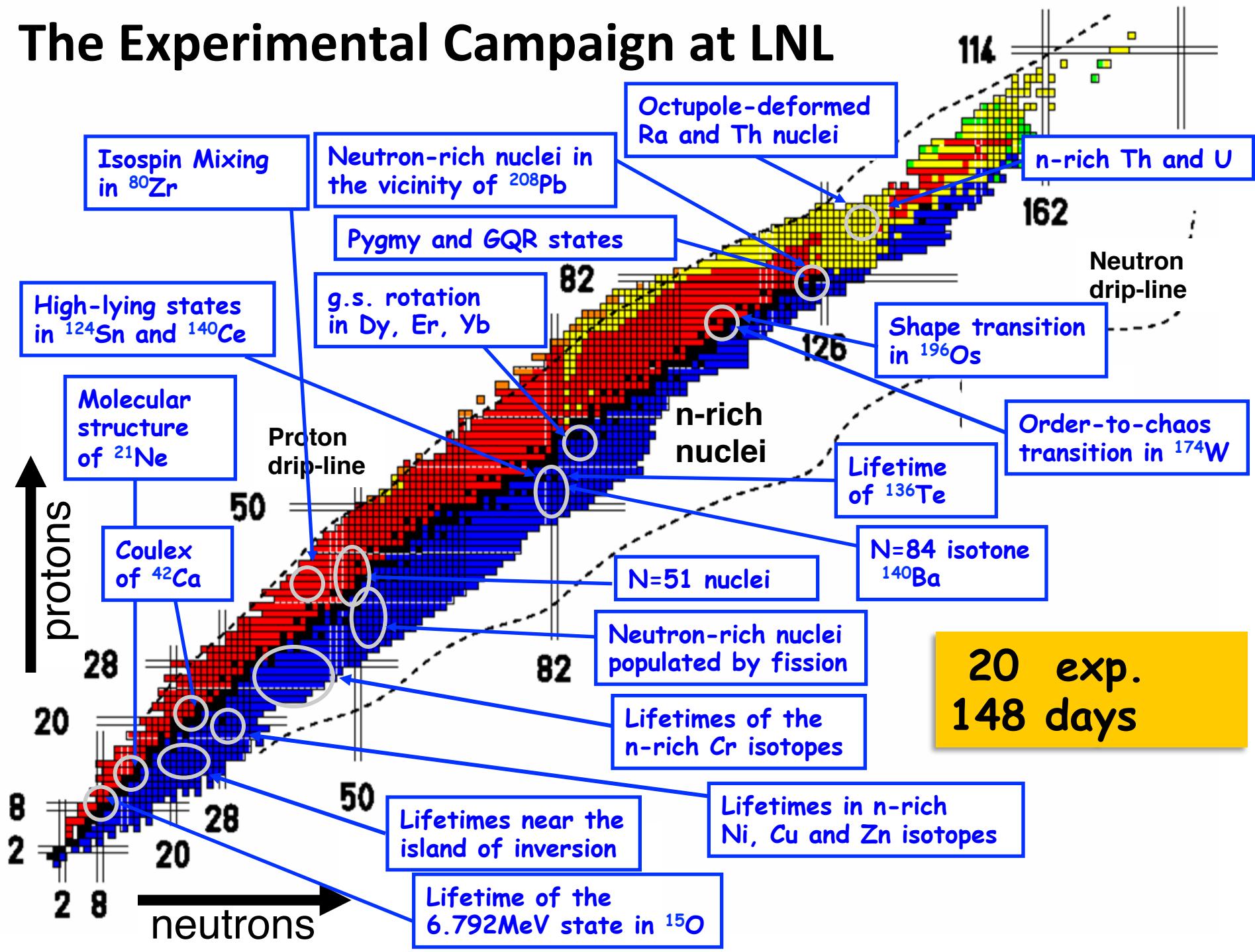
- Energy resolution restored thanks to position info from PSA and model of charge trapping during charge collection (Bart Bruyneel, 10th AGATA week, Nov. 2010, Lyon)
- Correction will improve with better-quality PSA
- **No frequent annealing of detectors needed !!**



The AGATA Demonstrator at LNL

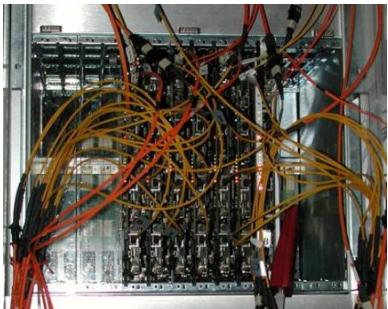
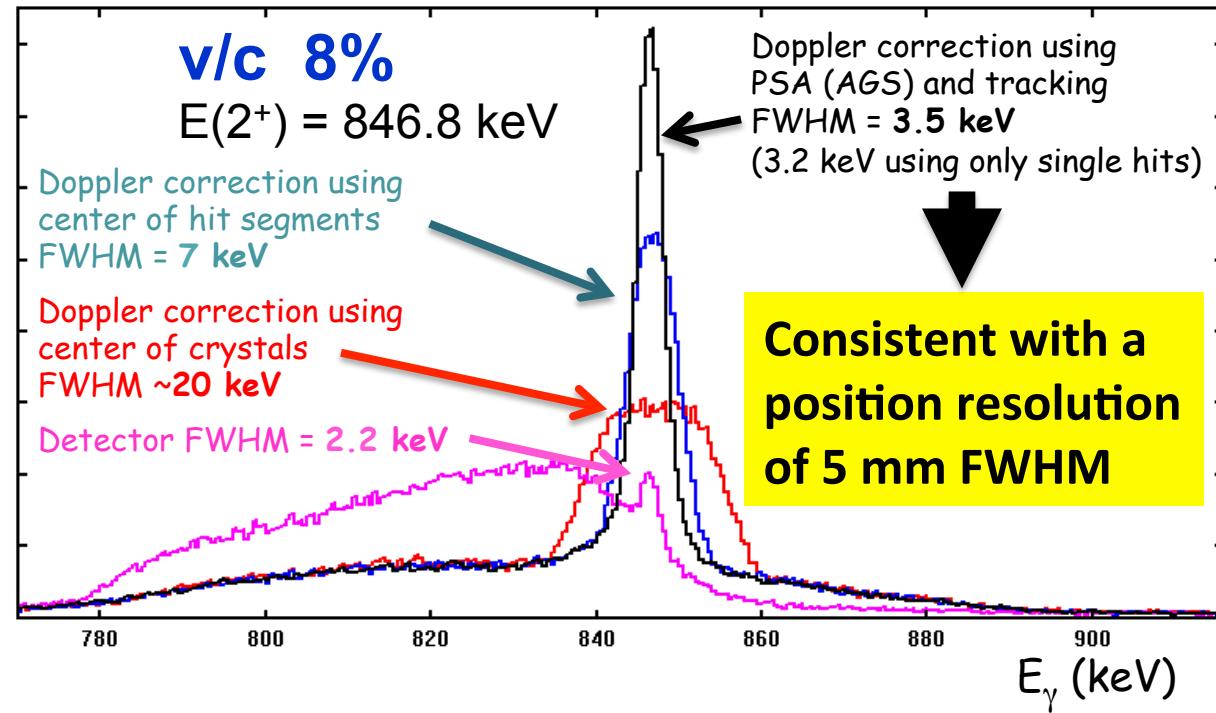
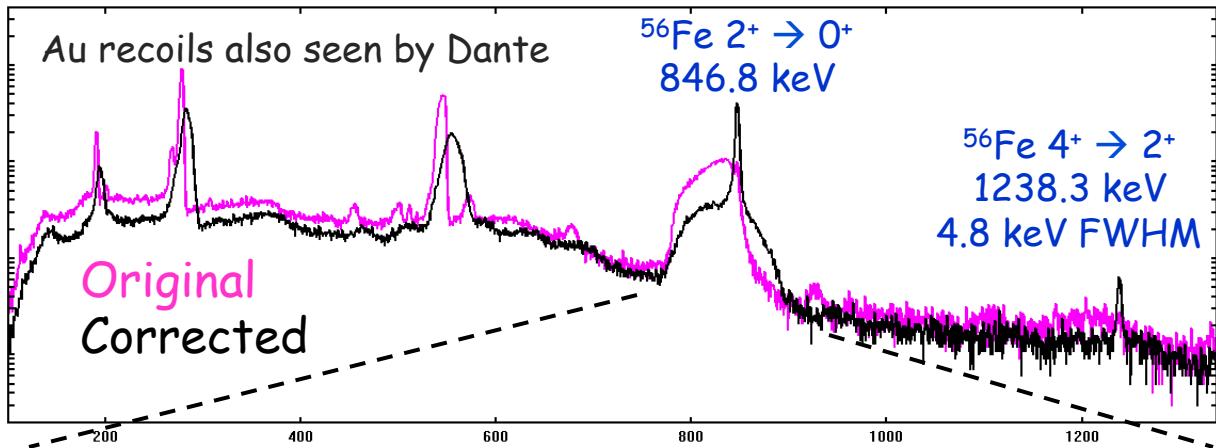
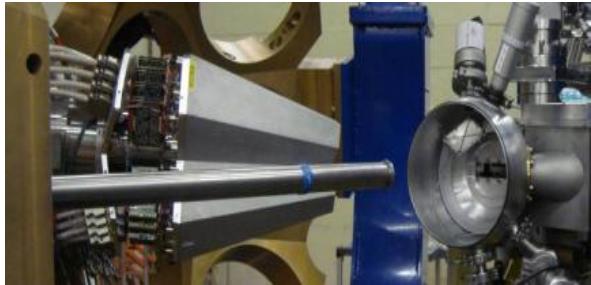
Just a few examples

The Experimental Campaign at LNL



Doppler Correction Capability, "small" v/c

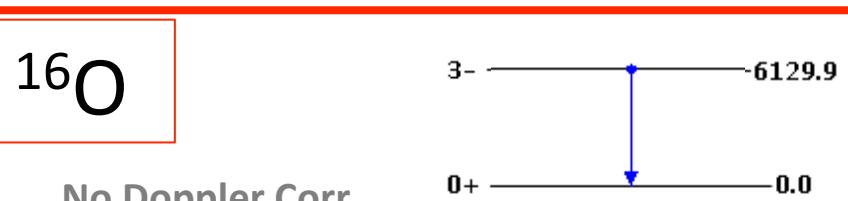
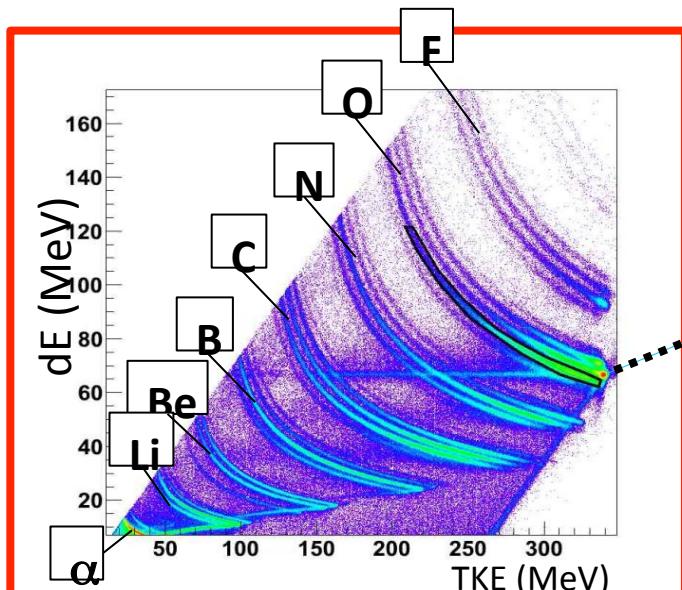
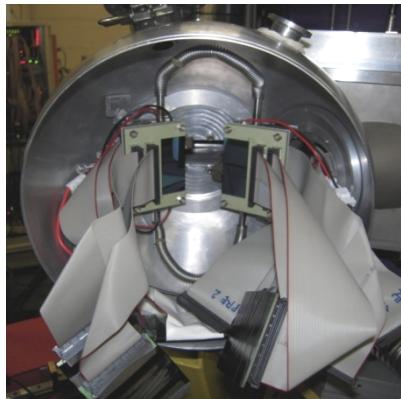
220 MeV $^{56}\text{Fe} \rightarrow ^{197}\text{Au}$ (ATC1 + DANTE, July 2009)



Doppler Correction Capability, “large” v/c

inelastic scattering ^{17}O @ 20 MeV/u on ^{208}Pb

Charged particles detected in TRACE

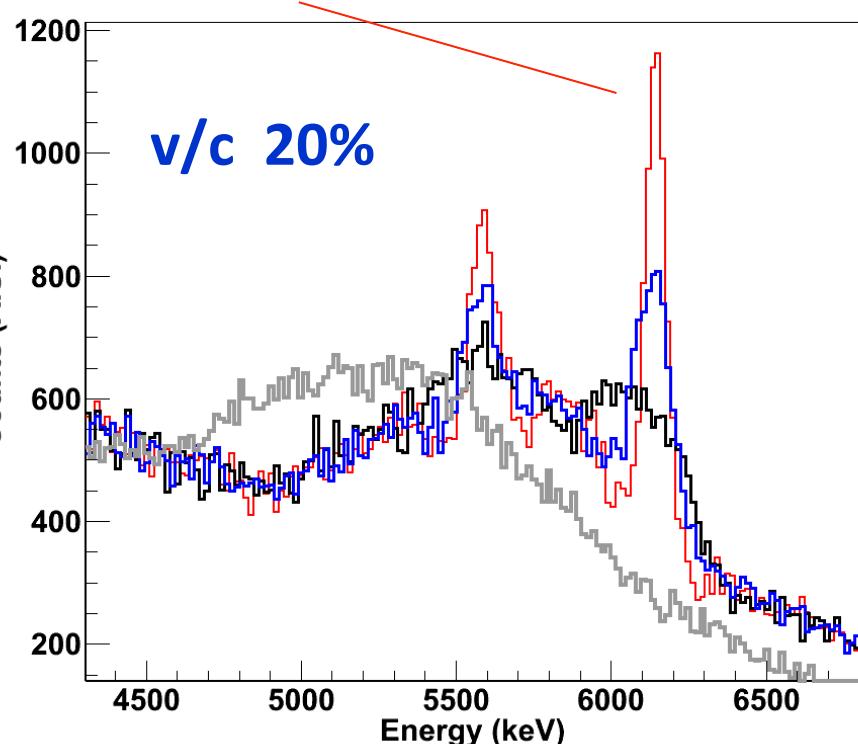


No Doppler Corr.

Crystal Centers

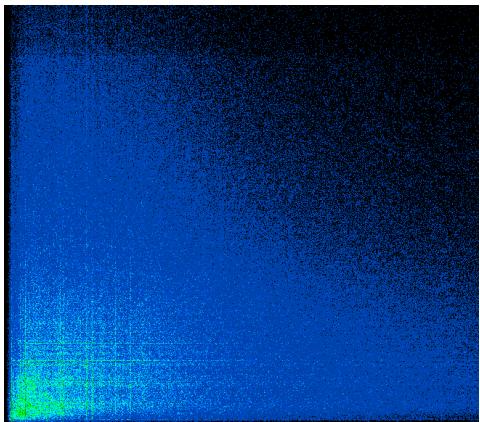
Segment Centers

PSA+Tracking

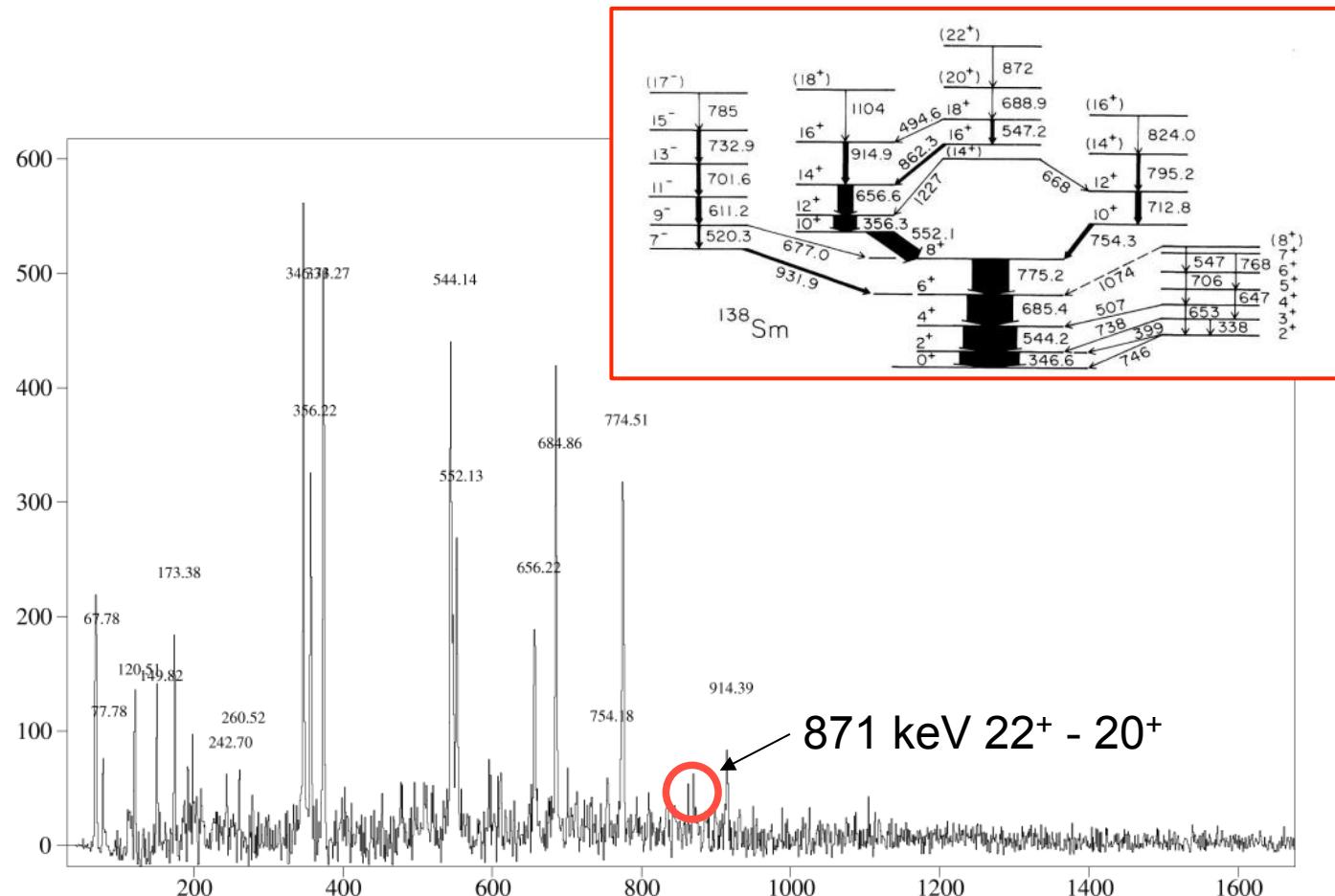


$\gamma\gamma$ capabilities

135 MeV $^{32}\text{S} \rightarrow ^{110}\text{Pd}$ (6 AGATA crystals only)

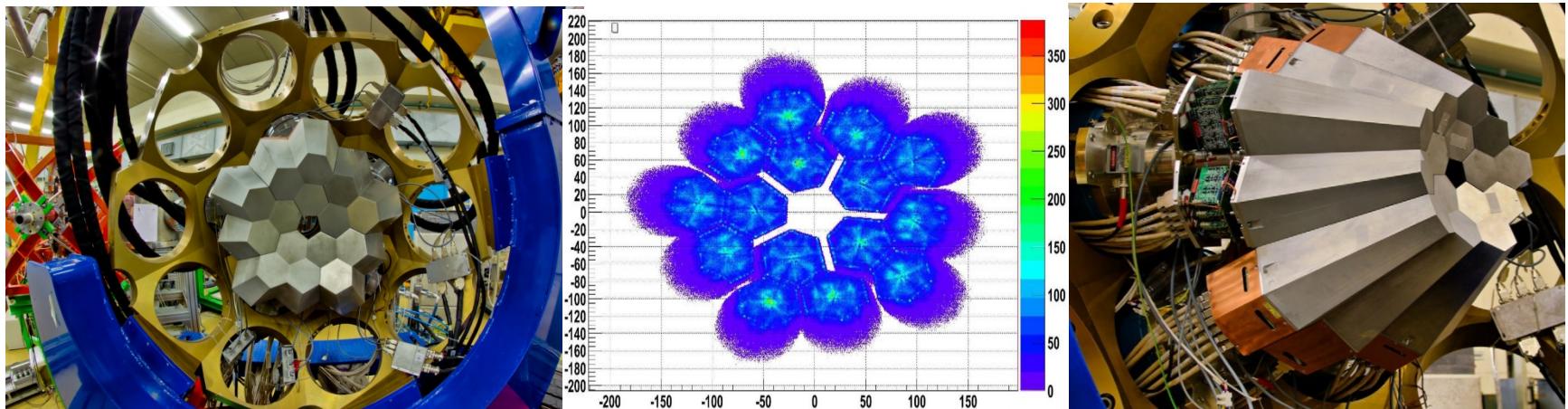
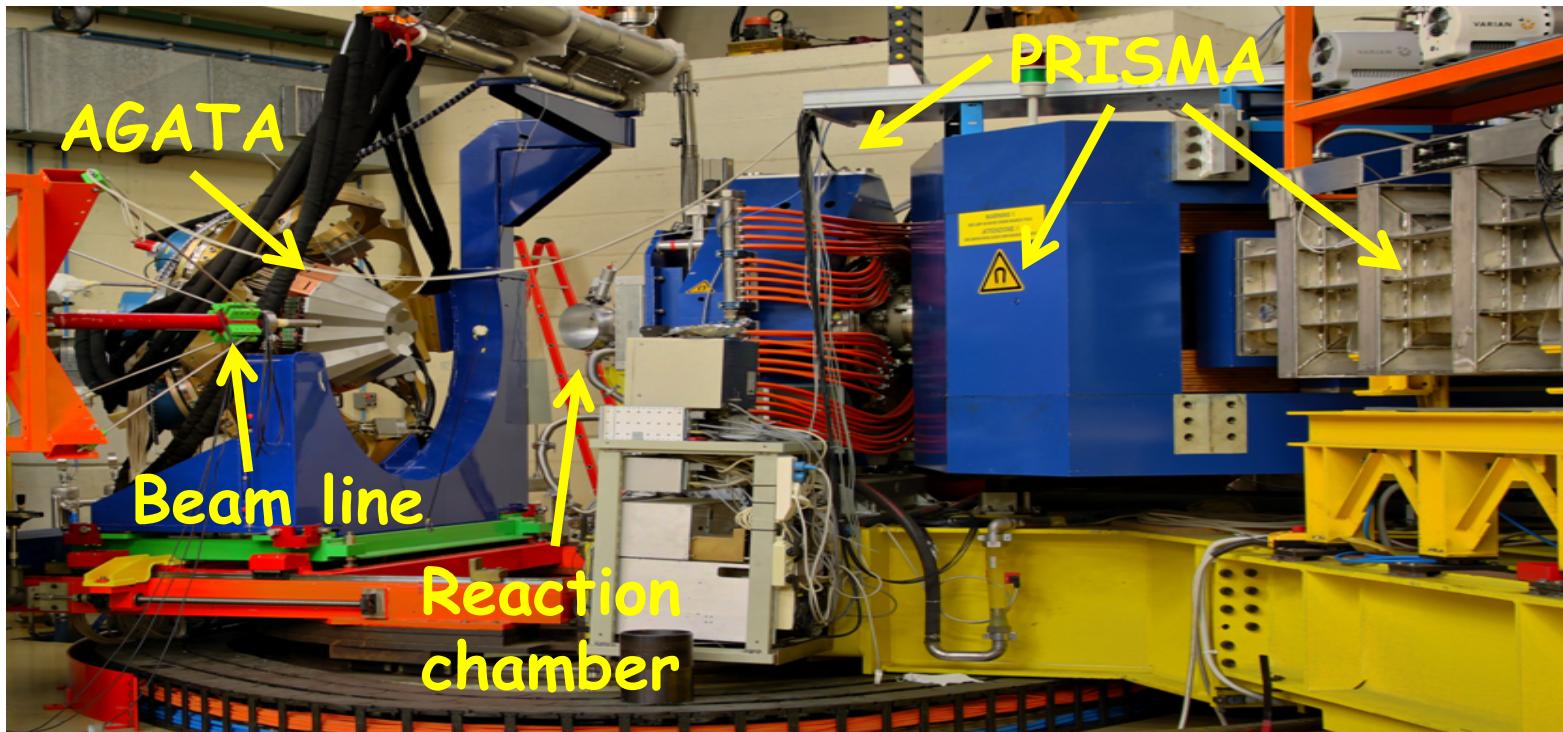


The performance of AGATA using γ -ray tracking is comparable to conventional arrays with a much larger number of crystals

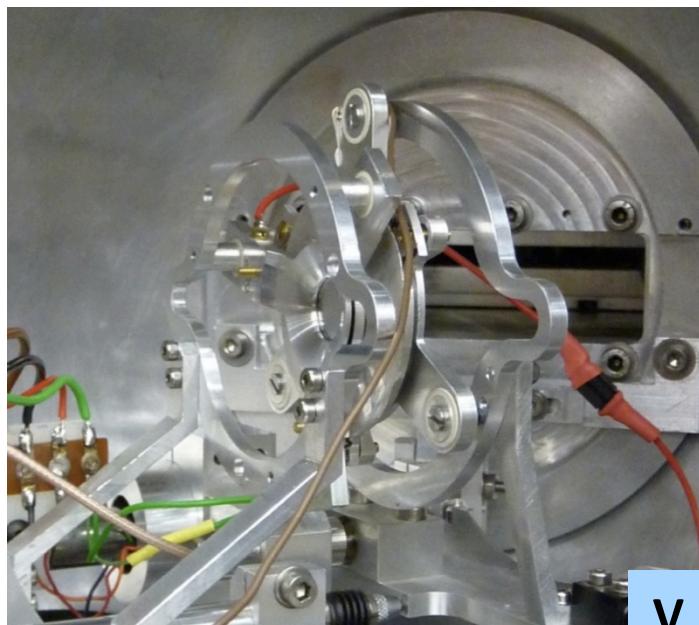
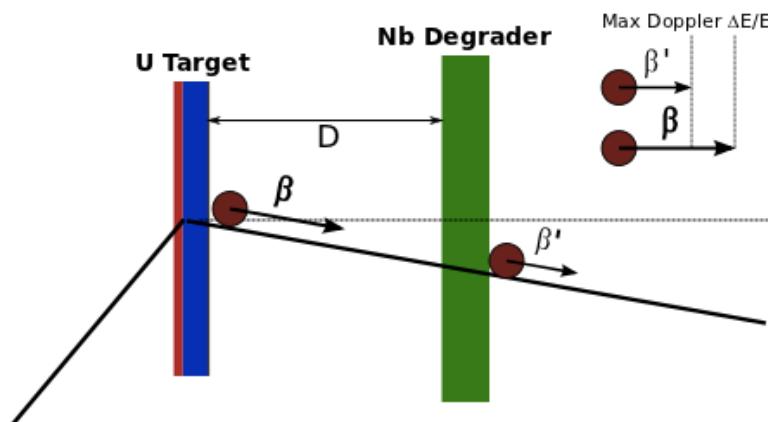
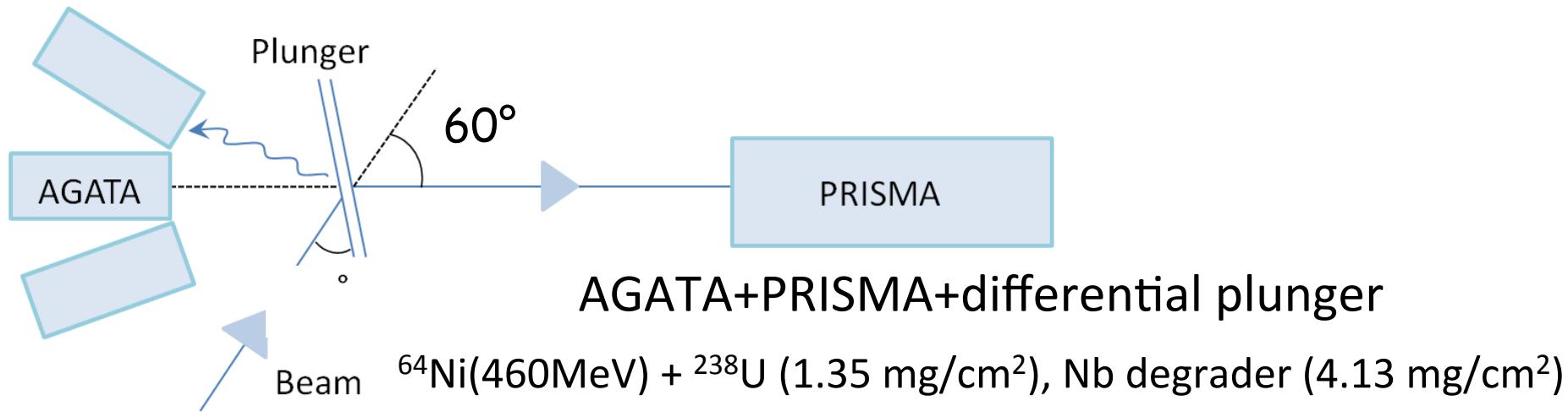


AGATA Demonstrator + PRISMA

infrastructure completed mid 2009, all clusters in place May 2011

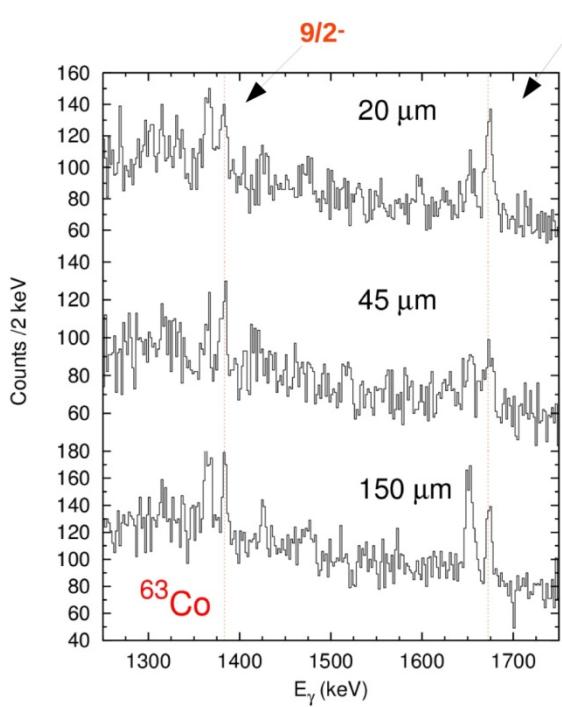


Lifetime measurement in neutron-rich Ni, Cu and Zn isotopes

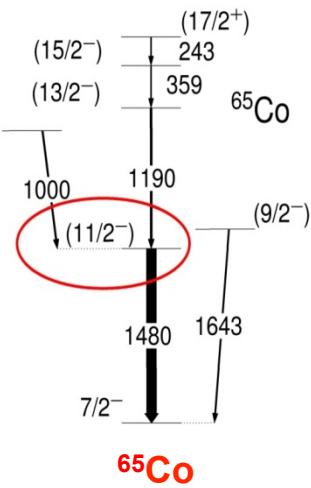
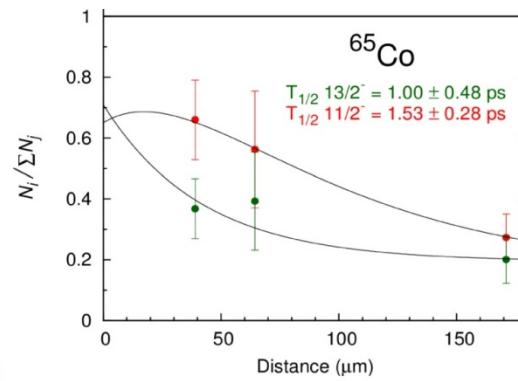
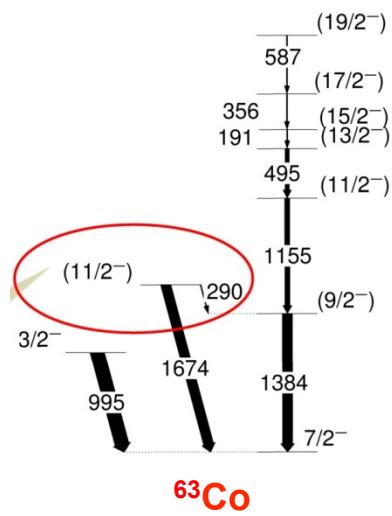
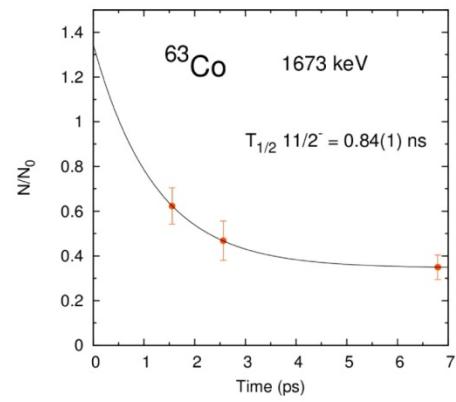
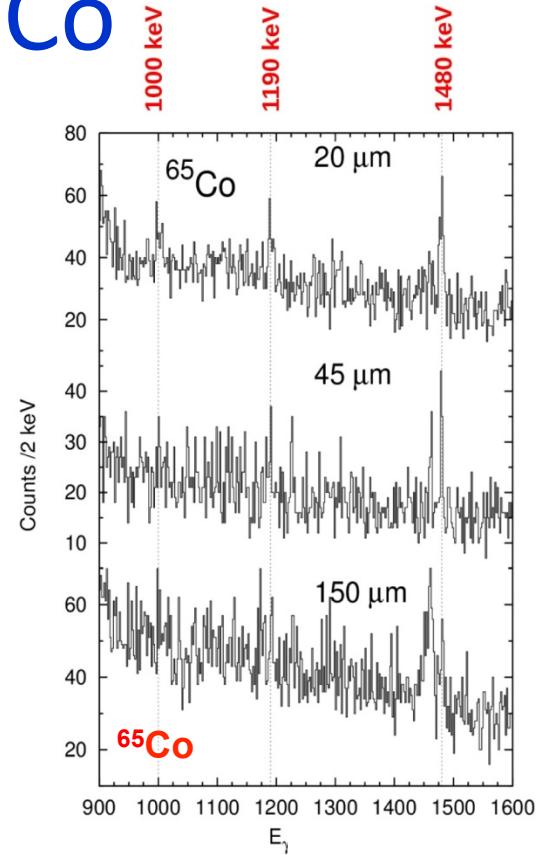


V. Modamio, LNL

Results for $^{63,65}\text{Co}$



V. Modamio, LNL



From the Demonstrator to AGATA 1 π

Plans for the next few years

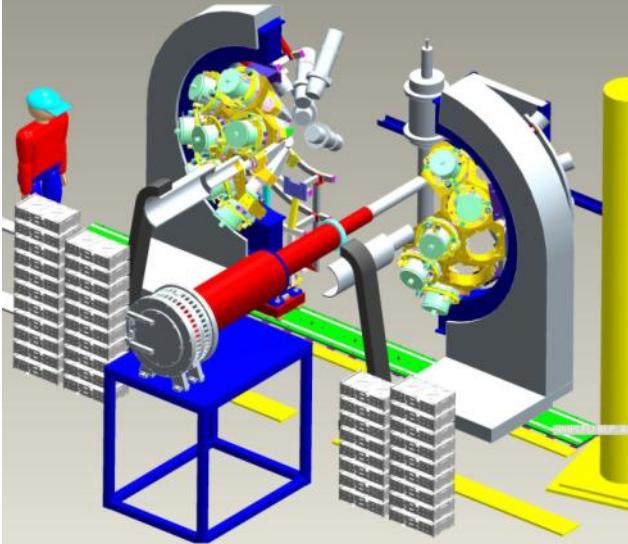
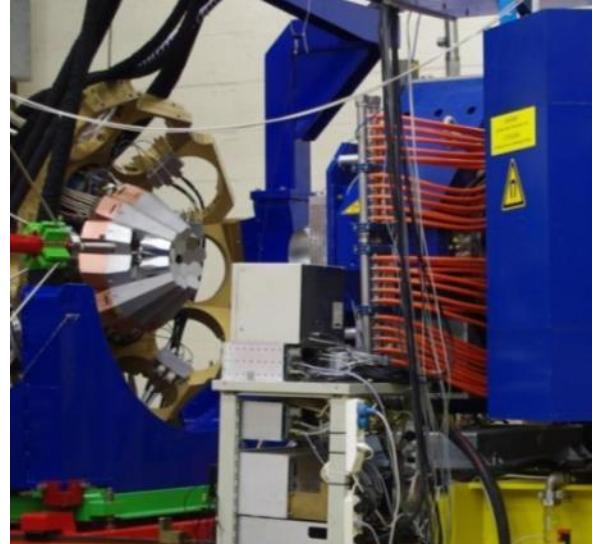
LNL: 2010-2011
5 TC
Total Eff. ~6%



GSI: 2012-2013
 \geq 5 TC + 5 DC
Total Eff. ~10%



GANIL: 2014-2015
15 TC
Total Eff. ~15%

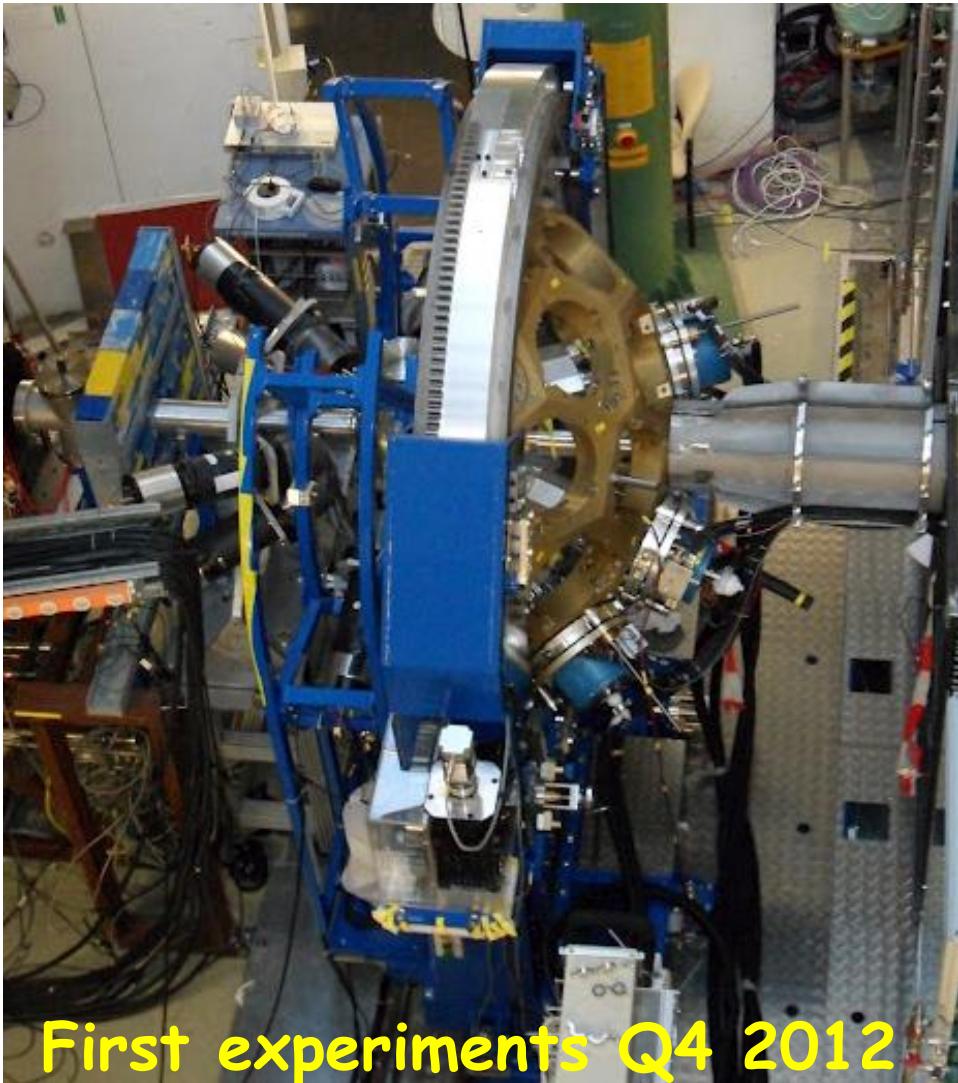


AGATA D.+PRISMA

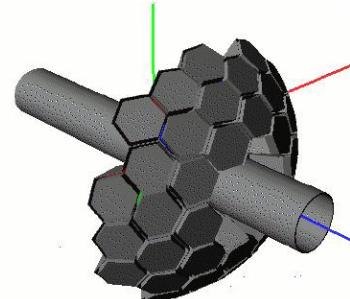
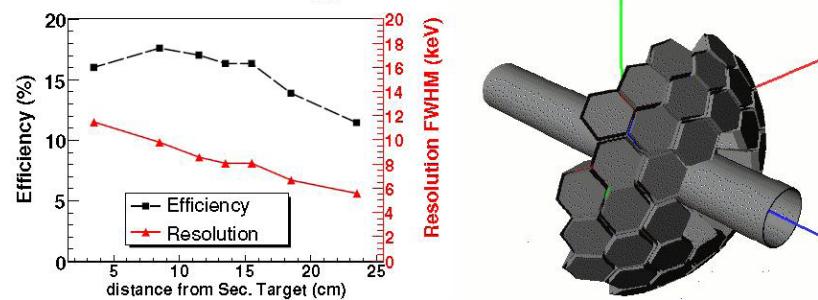
AGATA + FRS

AGATA+VAMOS

Status of AGATA at GSI



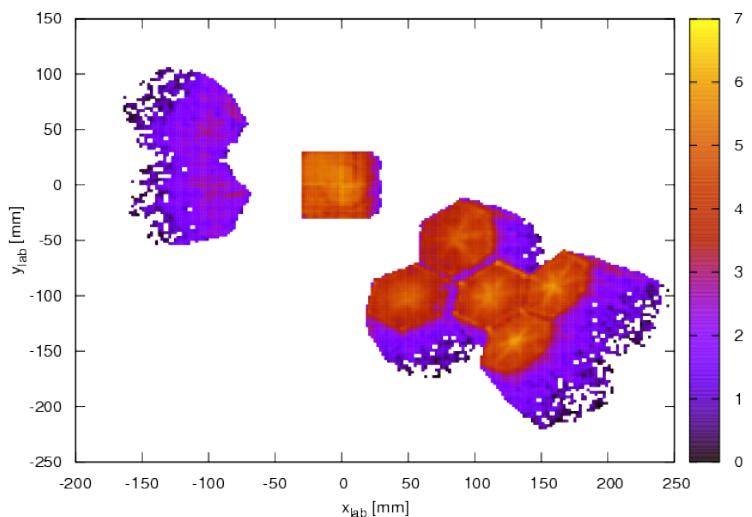
First experiments Q4 2012



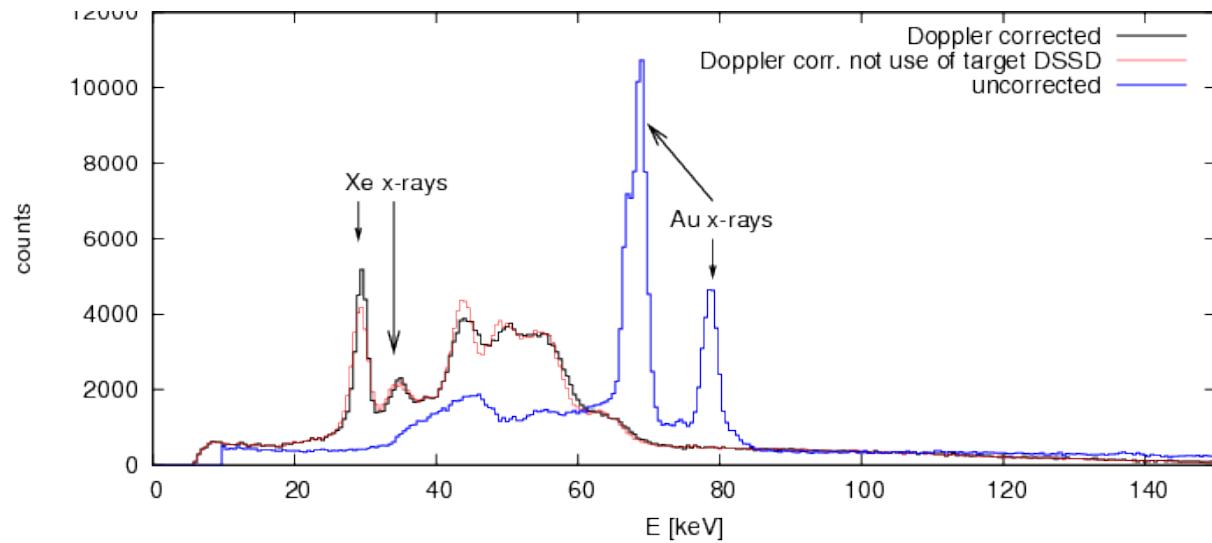
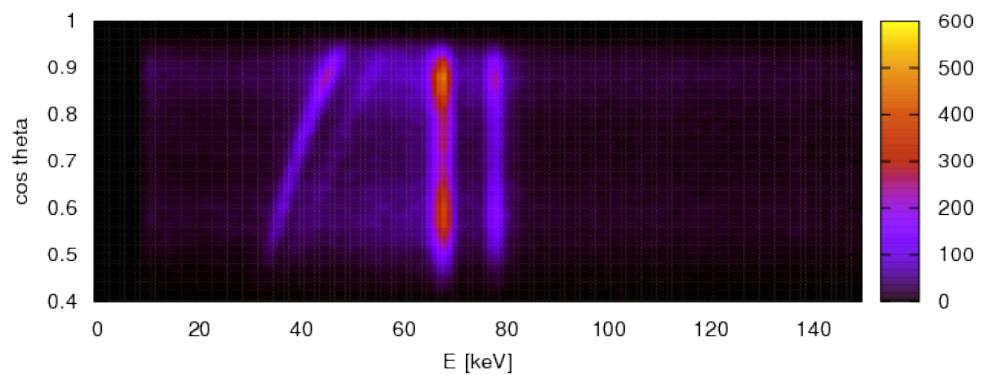
- New mechanics and detector support infrastructure ready
- Electronics and DAQ ready for 25 crystals
- Tests with fragmentation beams done in May-June 2012 with 7 crystals (2DC+1TC), coupled to FRS+LYCCA+HECTOR
- **20 crystals for experiments in Q4 2012**
- **25+ crystals for experiments in Q4 2013**

- AGATA has placed orders for 32 capsules (as of 2011)
- Availability for experiments is limited by delivery rate and reliability problems

AGATA at GSI

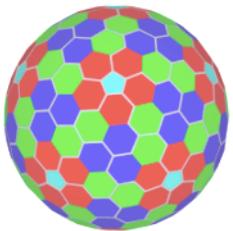


^{136}Xe (100-150 MeV/u)+ ^{197}Au



S. Pietri,

M. Reese, GSI



The AGATA Collaboration



Bulgaria: Sofia

Finland: Jyväskylä

France: GANIL, Grenoble, Lyon, Orsay, Saclay, Strasbourg

Germany: Darmstadt, GSI, Köln, München

Italy: Firenze, LNL, Milano, Padova

Poland: Krakow, Warsaw

Romania: Bucharest

Spain: Valencia, Madrid, Salamanca

Sweden: Göteborg, Lund, Stockholm, Uppsala

Turkey: Ankara, Istanbul

UK: Brighton, Daresbury, Edinburgh, Liverpool, Manchester, Paisley, Surrey, York